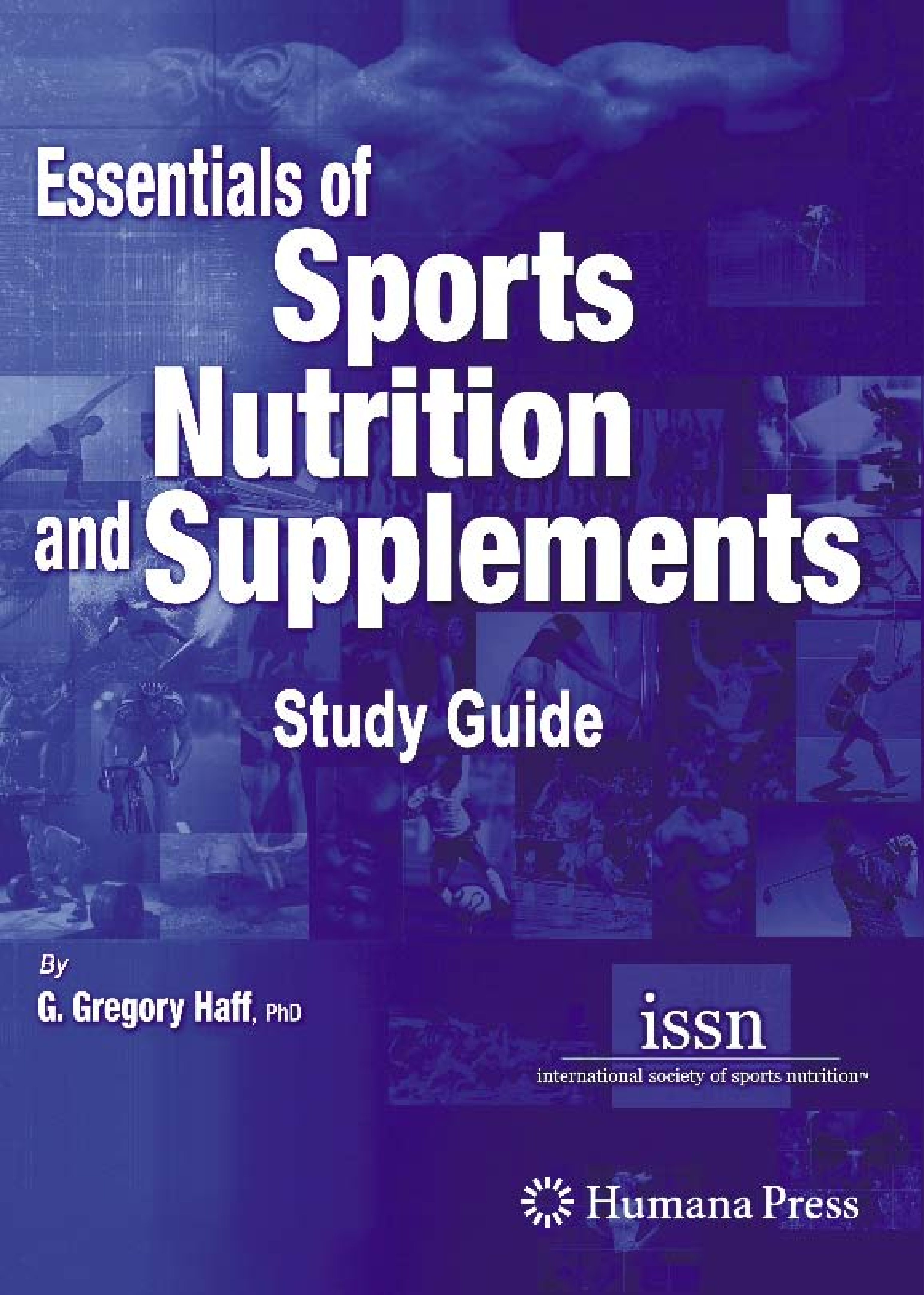

Essentials of Sports Nutrition and Supplements

Study Guide

By

G. Gregory Haff, PhD

issn

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Humana Press

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Preface

The *Essentials of Sports Nutrition Study Guide* serves as a resource companion to *Essentials of Sports Nutrition and Supplements* (2008), the official textbook for the International Society of Sports Nutrition's (ISSN) certification in sports nutrition. The *Study Guide* is designed to assist you in understanding and mastering the text content that is necessary to achieve certification. Materials covered focus on terms, key words, concepts, and other associated topics. To accomplish the goals of this text, each chapter follows the official text closely, allowing students to work through specific content areas. At the end of each chapter, there are sample quizzes. Answers to all sample quizzes are presented in the Appendix of the *Study Guide*.

The *Study Guide* is designed to allow the student to work through major content areas as they read the *Essentials of Sports Nutrition and Supplements* text. Education-based research suggests that material is best learned when students first read material and then write or work through exercises that require them to apply the material they have just covered. The *Study Guide* is designed to facilitate this by engaging students with materials that relate to the information presented in the *Essentials of Sports Nutrition and Supplements* text. Students are strongly encouraged to use the two texts concurrently, thus engaging in the process of active reading and active learning.

The *Study Guide* was created as a learning tool to help students prepare for the International Society of Sports Nutrition's certification in sports nutrition. I have been truly honored to be associated with the creation of a study guide that will help prepare students for the rigors of the ISSN's certification. I wish you the best of luck as you prepare and eventually move into the profession.

G. Gregory Haff, PhD
Morgantown, WV

Acknowledgments

First, I would like to take this opportunity to thank Jose Antonio for asking me to participate in this project. I am deeply honored that the ISSN has sought my involvement in this project. Second, I thank Dr. Michael Stone for inspiring me as a researcher, teaching me how to be a sports scientist, and for being more than a mentor—a true friend. Third, I thank all of my undergraduate and graduate students. You inspire me daily to be the best I can be. Your desire to learn and passion for exercise science make me excited to come to work every day. Finally, I thank the most important person in my life, my wife Erin, for allowing me to pursue all of my dreams and for believing in me no matter what challenges are thrust before me. Without you, I am nothing, and I appreciate all that you do for me.

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How to Use This Text

As you prepare for the International Society of Sports Nutrition's certification in sports nutrition, this study guide can serve as a valuable tool to help you understand and master the material presented in the *Essentials of Sports Nutrition and Supplements*. The best approach is to first read a specific chapter in the *Essentials* text. After completely reading a chapter, open the corresponding chapter in the *Study Guide*. Read the chapter objectives so that you can focus on the major areas of emphasis. You can then begin working through the learning exercises. Two approaches can be used: 1) you can use the *Study Guide* to test your knowledge of what you have read in the *Essentials* text, or 2) you can work through each learning exercise in conjunction with rereading the individual sections of the corresponding chapter in the *Essentials* text. The second approach allows for the student to do two things: 1) read the material, and 2) reread the material while actively working through specific exercises. After completing the learning exercises, look at the Review of Terminology and Important Abbreviations sections to make sure you understand each of the terms and abbreviations. Finally, there are 20 practice questions associated with each chapter that you can use as practice exams to test how well you have mastered the material in each chapter.

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Contents

Part I
Basic Exercise Physiology

1
Thermodynamics, Biochemistry, and Metabolism

Objectives

On the completion of this chapter, you will be able to:

1. Understand the different energy systems used for physical activity.
2. Know how to apply your knowledge of exercise bioenergetics to athletic training programs.
3. Understand how the principle of training specificity relates to exercise bioenergetics.

Learning Exercises

Exercise 1: Basic Introductory Definitions

_______ is often considered to be the capacity to do work or to cause change.

Define and give an example of energy transfer:

Bioenergetics is the ____.

What three things are related to the study of bioenergetics?

1.

2.

3.

Exercise 2: Understanding Thermodynamics

What are the two components of the 2nd Law of Thermodynamics?

1.

2.

The transfer of high energy content to low energy content is an example of a ________________.

Explain what happens during combustion. In this explanation, discuss the major players.

The greater the content of e^- and H^+ within a fuel the _____ the energy content present in that fuel source.

What are the two low energy end products of combustion?

1.

2.

The biologic equivalent of combustion is termed __________________.

When examining the transfer of heat to mechanical motion, define the following terms:

Heat:

Temperature:

Efficiency:

Give examples of the efficiency of energy transfer for the following engines:

Steam engine:

Gasoline powered engine:

Diesel engine:

Human pedaling a bicycle:

Define the 1st Law of Thermodynamics:

Exercise 3: Energy Transfer

Define and describe the three types of systems:

1.

2.

3.

Match the term with the appropriate abbreviations:

Enthalpy:____________________	A: *S*
Entropy:____________________	B: G
Gibbs Constant:______________	C: H

Define the following terms:

1. Enthalpy:
2. Entropy:

Taking enthalpy, entropy, and the Gibbs' constant, write a basic equation that explains energy transfer:

$$\quad = \quad + \quad$$

In the grand scheme of energy transfer, what does entropy represent?

The total amount of energy that is available for use is termed _______, which is dependent on the total energy within a system and its immediate environment, which is represented by ______, and how much energy is unavailable or ________.

Taking the concept that Gibbs' recognized that enthalpy and entropy are the driving force behind energy transfer, write an equation that represents this.

$$= \quad\quad - $$

When looking at an open system, what two things should be considered?

1.

2.

As the rate of energy transfer increases, the efficiency of energy transfer ________.

Open systems are better explained in regards to a particular status in between beginning and end points. In this context, explain the following:

1. What is the symbol for the rate of energy exchange? __________
2. What is the symbol for the extent of metabolic product formation from reactants? ____________
3. What is the symbol for Gibbs energy? ____________

Write an equation that explains the relationship between Gibbs energy, the rate of energy exchange, and the extent of metabolic production formation from biochemical reactants.

$$\star$$

What about an open system makes heat and entropy inevitable and continuous? What does this result in?

When looking at life, explain the relationship between the food we eat and the energy available to us and the heat we produce. In this example, relate entropy, enthalpy, and Gibbs energy to your discussion.

Exercise 4: Biochemistry

The flow of _____ and _____ is often termed oxidation-reduction reactions by scientists.

Define the two parts of an oxidation-reduction reaction:

1. Oxidation:
2. Reduction:

Define and describe the role of enzymes in the biochemistry of bioenergetics:

Explain what allosteric regulation is and how it affects enzyme activity.

Define the following terms:

1. Catabolic:
2. Anabolic:
3. Anaerobic:
4. Aerobic:

ATP: The High-Energy Phosphate and More High-Energy Phosphates

Define the following abbreviations:

1. ATP:
2. ADP:
3. AMP:
4. Pi:
5. CP:
6. C:

What is the ratio of ATP to ADP kept at? Why is this significant?

What two things does ATP turnover consist of?

1.
2.

What does the rate of ATP hydrolysis dictate?

What are the three single enzyme reactions that contribute to energy transfer in anaerobic metabolism?

1. Enzyme = __________________

+ → + + + + +

2. Enzyme = __________________

+ + → + +

3. Enzyme = __________________

→ + +

When creatine phosphate stores are significantly depleted, the rate at which physical work is performed is significantly ________________.

What does a high concentration of lactate in the muscle and blood indicate?
Explain why an athlete might consider ingesting baking soda and why this might not be the best idea.

The mitochondria degrade glucose to _____________ and _____________.

What are the two distinct parts of aerobic metabolism?

1.

2.

What are the three alternative names for aerobic metabolism?

1.

2.

3.

What coenzyme must be linked to a substrate for it to enter into the Krebs cycle?

What are the names of the two special carrier molecules that e^- and H^+ are attached to and are used to link the first part of aerobic metabolism to the second part?

Explain what a joule is and how it relates to a unit of heat (energy).

Explain the difference between direct and indirect calorimetry.

1. Direct calorimetry:
2. Indirect calorimetry:

Explain what the respiratory exchange ratio is.

1. What would the RER be if the amount of CO_2 produced equally matched the amount of O_2 consumed?
2. What would the RER be if you were primarily metabolizing fat?
3. Explain the relationship between intensity of exercise and the RER.

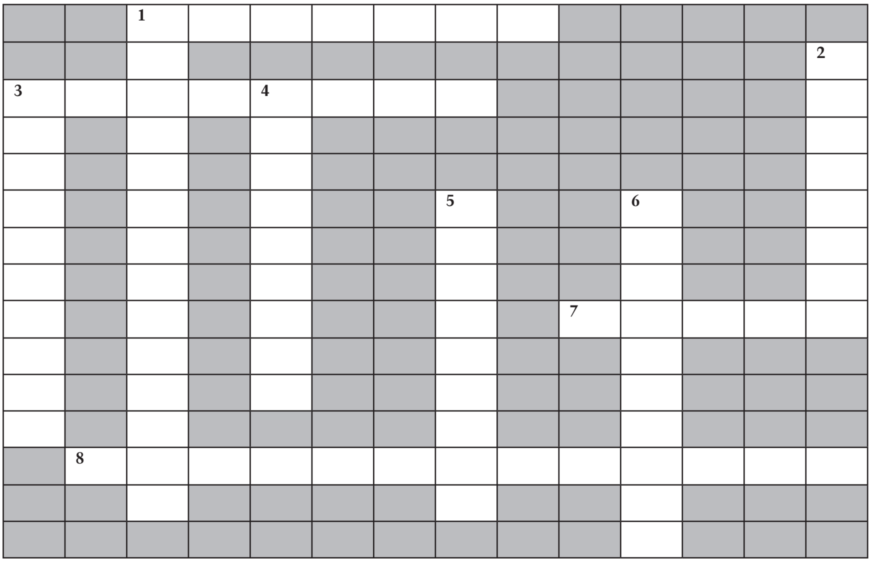
Explain the difference in the rate of ATP resynthesis between anaerobic and aerobic mechanisms.

What is the oxygen deficit and what does it represent?

What is EPOC and what factors contribute to it?

What three measures are needed for the interpretation of total energy expenditure during exercise and recovery?

1.
2.
3.



Across:

1. Serves as an electron and hydrogen donor in glycolysis
3. Storage form of carbohydrates in the body
7. A unit of measurement used to represent work
8. Is the site of aerobic respiration, often called the powerhouse of the cell

Down:

1. The breakdown of glycogen in the body
2. Accepts an electron and a hydrogen during glycolysis
3. The breakdown of glucose in the body
4. The loss of electrons and protons
5. The gain of electrons and protons
6. An intricate and highly modifiable internal arrangement of protein fibers

Review Test

1. The two most important hydrogen (electron) carriers in bioenergetic chemical reactions are:
   a. NAD^+ and ATP
   b. FAD^+ and ATP
   c. NAD^+ and FAD^+
   d. NAD^+ and LDH

2. A respiratory quotient (RQ) of 0.95 during steady-state exercise is suggestive of a(n):
   a. High rate of carbohydrate metabolism
   b. High rate of fat metabolism
   c. Equal rate of fat/carbohydrate metabolism
   d. High rate of protein metabolism

3. A respiratory quotient (RQ) of 0.75 during steady-state exercise is suggestive of a(n):
   a. High rate of carbohydrate metabolism
   b. High rate of fat metabolism
   c. Equal rate of fat/carbohydrate metabolism
   d. High rate of protein metabolism

4. The breakdown of glucose occurs in a process termed:
   a. Glycogenolysis
   b. Oxidative phosphorylation
   c. Glycolysis
   d. None of the above

5. The first law of thermodynamics states that energy transfer operates at an efficiency.
   a. True
   b. False

6. A reduction reaction involves the:
   a. Gain of electrons
   b. Loss of hydrogen molecules
   c. Loss of electrons
   d. Gain of hydrogen molecules
   e. b and c
   f. a and d
   g. c and d

7. An enzyme functions as catalysts which increase the rate of spontaneous reactions.
   a. True
   b. False

8. The myokinase reaction results in the production of _______ and _______.
   a. ADP and Pi
   b. ATP and AMP
   c. ATP and ADP
   d. ADP and AMP

9. Direct calorimetry measures:
   a. Metabolic rate through oxygen consumption
   b. Metabolic rate through heat production
   c. Oxygen consumption with open circuit spirometry
   d. Oxygen consumption with closed circuit spirometry

10. ATP hydrolysis and resynthesis both contribute to ATP turnover.
    a. True
    b. False

11. The simplest and most rapid method to produce ATP during exercise is through:
    a. The glycolytic system
    b. The high-energy phosphate system
    c. Aerobic metabolism
    d. Glycogenolysis

12. The effect of heavy/severe exercise on substrate-level phosphorylation:
    a. Increase
    b. Decrease
    c. No effect

13. Blood lactate is an excellent indicator of glycolytic ATP turnover.
    a. True
    b. False

14. During EPOC, the principle nutrients used with oxidative means are lactate and fat.
    a. True
    b. False

15. The primary energy system utilized during an 800-meter run receives its energy from?
    a. High-energy phosphates
    b. Oxidative mechanisms
    c. Glycolytic mechanism
    d. None of the above

16. Enthalpy can be defined as the initial or total energy content within or available to a system.
    a. True
    b. False

17. The potential influence of substances on the activity of enzymes is termed allosteric regulation.
    a. True
    b. False

18. All of the following are true about ATP turnover except:
    a. ATP hydrolysis fuels cellular work
    b. ATP resynthesis occurs via energetic pathways
    c. The rate of ATP resynthesis dictates the rate of ATP hydrolysis
    d. a and b
    e. a and c

19. What is the effect of a drop off of creatine phosphate on the rate at which physical activity can be performed?
    a. Increased performance
    b. Decreased performance
    c. No effect on performance

20. Aerobic metabolism is also known as:
    a. Krebs cycle
    b. Glycolysis
    c. Tricarboxylic acid cycle
    d. All of the above
    e. a and b
    f. b and c

Review of Terminology

Introduction	**Energy Transfer**	**Adenosine Triphosphate: The "High-Energy" Phosphate**
Bioenergetics	Closed System	Adenosine Diphosphate
Energy	Enthalpy	Adenosine Monophosphate
	Entropy	Adenosine Triphosphate
Thermodynamics	Isolated System	Chemo-Mechanical
Combustion	Open System	Hydrolysis
Efficiency	Closed System	
Gradient		**More "High-Energy" Phosphates**
Heat	**Biochemistry**	Alkalosis
Metabolism	Aerobic	ATP/ADP Ratio
Temperature	Allosteric Regulation	Creatine Kinase
	Anabolic	Creatine Monohydrate
Glycolysis	Anaerobic	Creatine Phosphate
Glycogen	Catabolic	Myokinase
Glycogenolysis	Enzymes	
Glycolysis	Feed-Backward	**Respiration**
Lactate	Feed-Forward	Acetyl-CoA
Pyruvate	Oxidation	Citric Acid Cycle
	Reduction	Flavin-Adenine Dehydrogenase
Energy Expenditure		Krebs Cycle
Calories	**Sidebar 1.1**	Macronutrients
Direct Calorimetry	Convection	Mitochondria
Excess Postexercise Oxygen Consumption	Cytomatrix	Nicotinamide Adenine Dehydrogenase
Indirect Calorimetry	Lactate Dehydrogenase	Respiration
Joule		Tricarboxylic Acid Cycle
Oxygen Deficit	**Sidebar 1.3**	
Respiratory Exchange Ratio	Maximal Oxygen Uptake	**Practical Applications**
Steady State		Electrocardiogram
Total Energy Expenditure		Slow O_2 Component
Work		

Important Abbreviations

∂	FAD^+
ζ	G
ΔG	H
ΔH	H^+
Δ*S*	H_2O
ADP	LDH
AMP	Mol
ATP	NAD^+
C	O_2
CO_2	Pi
CoA	Red-Ox
e^-	RER
EKG	S
EPOC	TEE
ETC	VO_2 max

2
Skeletal Muscle Plasticity

Objectives

On the completion of this chapter, you will be able to:

1. Define the basic definitions associated with bioenergetics.
2. Understand the basic principles behind thermogynamics.
3. Develop an understanding of the concept of energy transfer.
4. Describe the biochemical reactions associated with various energy-transfer pathways in the body.
5. Explain the basics of energy expenditure, the methods for measuring energy expenditure, and the relationship of energy expenditure to exercise.

Learning Exercises

Exercise 1: Defining Layers of Connective Tissue in Skeletal Muscle

List the three major connective tissue layers found in skeletal muscle:

1. ______________________________________
2. ______________________________________
3. ______________________________________

The ___________ surrounds the bundles of muscle fibers which are called ______________.

The __________ surrounds each muscle fiber and separates it from adjacent fibers.

The deep fascia or _________________ surrounds the entire muscle.

Exercise 2: Describing and Defining the Muscle Fibers and Architecture

Explain the characteristic of skeletal muscle fibers that allows more myofibers to be packed into a given volume of muscle.

Explain the difference between fusiform and pennate muscles.

List the three types of pennate muscle seen in the body:

1. ______________________________
2. ______________________________
3. ______________________________

Define and describe the following terms:

1. Inscriptions:
2. Serially Arranged Fibers:
3. Pennate Fiber Arrangements:

Exercise 3: Understanding the Skeletal Muscle Fiber

The Sarcolemma

Define the function and structure of the sarcolemma.

What are the primary structures involved in the development of the difference in electrical potential across the sarcolemma?

The Neuromuscular Junction

Describe the structures that comprise the neuromuscular junction.

The neurotransmitter _____________ is released from the vesicles in the synaptic knobs.

The ____________ is the very small space that separates the muscle fiber from the motor neuron.

List the three major structures associated with the neuromuscular junction:

1. _____________________________
2. _____________________________
3. _____________________________

The Transverse Tubules and Sarcoplasmic Reticulum

List the two structures that are part of the elaborate system of channels that are needed in order to activate the myofiber:

1. _______________________________
2. _______________________________

The _________ allow the action potential to be propagated deep into the core of the muscle fiber.

The _________ which are voltage sensing proteins lie in the _______ membrane and trigger the release of calcium from the ___________ through the ___________ receptors.

The _____________ has a network of cross-connections which are more complex in fast-twitch fibers.

The activation of a skeletal muscle during contractions causes a rapid diffusion of Ca^{2+} into the sarcoplasm by the _______________.

Define and describe what SERCA is and its role during muscle relaxation.

Sarcoplasm and Cellular Organelles

Define and describe sarcoplasm.

What are some of the structures that are in the sarcoplasm?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

"The powerhouse of the cell" is where oxidative metabolism occurs within the myofiber. This structure is also called the _______________.

Define and explain a myofibril.

Define and describe the structure and function of a sarcomere.

Describe the structure and function of the Z lines.

Exercise 4: Muscle Contractile and Regulatory Proteins

Name the two major contractile proteins that make up the sarcomere:

1. ______________________________
2. ______________________________

How many myosin heavy chain (MHC) molecules does myosin contain?

How many myosin light chain (MLC) molecules does myosin contain?

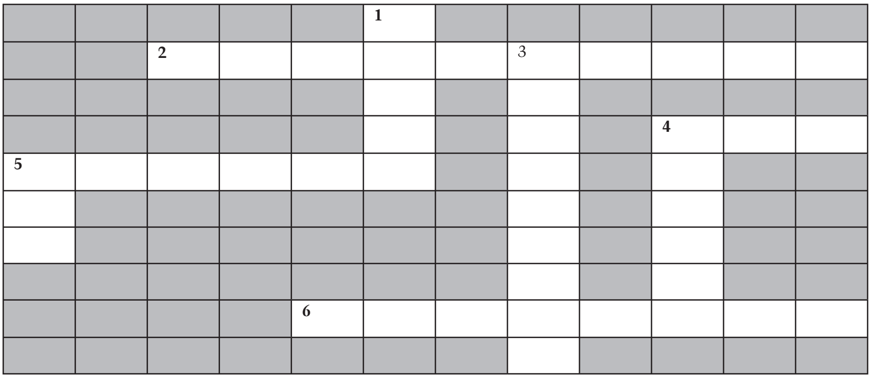
How many pairs of MHC molecules are intertwined to form the thick filament?

The globular head or the ________ projects outward toward the thin filament.

The __________ molecule is also known as the thin filament.

In complete detail, describe the organization of the thick filament.

Summarize the role of two regulatory and two essential myosin light chains.



Across:

2: The smallest functional unit of skeletal muscle
4: Compound broken by myosin ATPase
5: The thick filament
6: Serves as a skeleton or scaffold for the sarcomere

Down:

1: The thin filament
3: Long cylindrical filament that extends the length of the muscle fiber
4: Enzyme found as an intrinsic part of the globular head of myosin
5: Myosin contains two molecules of this structure

List and summarize the function of the three major components of a thin filament:

1. ___________:

2. ___________:

3. ___________:

List and describe the two types of actin molecules:

1. ____________:

2. ____________:

List and describe the functions of the three subunits of troponin:

1. ____________:

2. ____________:

3. ____________:

In detail, summarize the relationships and interactions of actin, tropomyosin, and troponin.

Diagram the basic structure of a muscle sarcomere including actin, myosin, Z lines, I band, A band, and H zone.

Exercise 5: Cytoskeleton Function and Structures

Describe and summarize the structure of titin and its relationship to myosin.

List the three functions that might be related to titin:

1.

2.

3.

Describe and summarize the structure and functions of nebulin.

The group of proteins that are termed intermediate fibers contains _________ which is a protein that links adjacent sarcomeres at their Z lines.

Summarize the role of dystrophin in stabilizing the sarcolemma during contraction. In this description, discuss how this protein relates to Duchenne muscular dystrophy.

Exercise 6: Skeletal Muscle Actions

Define the following terms:

Dynamic Muscle Action:

Concentric Muscle Action:

Eccentric Muscle Action:

Plyometric Muscle Action:

Isometric Muscle Action:

List the events/steps that lead from the excitation of the central nervous system to the propagation of the myofiber action potential on the sarcolemma.

List the events that lead from the propagation of the action potential on the sarcolemma until muscular contraction.

In detail, explain the process of cross-bridge cycling and the sliding filament theory.

Summarize the process by which a muscle relaxes:

Exercise 7: Classification of Muscle Fibers and Motor Unit Types

List and explain the characteristics of the three classifications of muscle fibers that are based on the contractile and metabolic properties of the myofibers:

1. ________________:

2. ________________:

3. ________________:

What are the three major fiber types based on the staining for myosin ATPase and what are some of their characteristics?

1. ________________:
2. ________________:
3. ________________:

What is the isoform of MHC important in determining? Explain why.

In the following table, fill in the major biochemical and contractile characteristics associated with the three major classifications of skeletal muscle.

	Slow oxidative	Fast oxidative glycolytic	Fast glycolytic
Biochemical properties			
Myosin ATPase		Moderately high	
Oxidative capacity	High		
Glycolytic capacity			High
Resistance to fatigue			
Contractile proteins			
Shortening velocity			Fastest
Relaxation		Fast	
Specific tension	Moderate		
Power		High	
Structural proteins			
Mitochondrial density	High		
Z line thickness		Intermediate	
M line thickness			3 M-bridges
Sarcoplasmic reticulum			

In the following table, fill in the major characteristics of the major motor unit classifications.

	S	FR	FF
Resistance to fatigue			
Oxidative capacity			
Force-generating capacity			
Twitch characteristics			
Innervation ratio			
Amount of synaptic input			
Soma size			
Axon size			

Is the fiber type of an athlete the only contributor to success in sports? If not, what other factors contribute?

If you reinnervate a fast-twitch muscle fiber with the motor nerve associated with a slow-twitch muscle fiber, what happens?

What happens to fiber type when an athlete undergoes endurance or strength training? To what extent do fibers transition with type and between types?

When examining biopsy data from various types of athletes, what types of fibers are associated with distance runners, sprinters and cyclists? Be specific in classifying type I, type IIA, and type IIx fibers.

Exercise 8: Factors Determining Muscular Strength

What are two biomechanical factors that affect an individual's ability to exert force? Explain how alterations in these factors affect force production.

1. ______________________:

2. ______________________:

Explain the force-tension relationship. What is the optimal sarcomere length and what happens if a sarcomere is shortened or lengthened?

What is the force-velocity relationship and how does this concept differ among type IIx, IIa, and I muscles?

How does power-generating capacity relate to force- and velocity-generating capacity?

Exercise 9: Regulation of Muscle Force Production

What is Henneman's size principle of motor unit recruitment and how does it operate in relationship to the amount of force encountered?

What are the two major strategies for modulating force production and how do they operate?

1. ____________:
2. ____________:

What is the difference between multiple motor unit summation and wave summation?

In detail, explain the process by which a twitch is developed and how it can transition into tetanus. In this discussion, explain the role of the SERCA pumps.

What is synchronization and how does it relate to the rate of muscular force production?

What are the major factors that have been suggested to cause fatigue?

What are four major sensory receptors associated with skeletal muscle and what do they do?

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

What is proprioception and what are the two major proprioceptors in skeletal muscle?

Describe the major components and functions of the Golgi tendon organs.

What is the function of a muscle spindle?

Draw the major components of a muscle spindle.

What are the two types of sensory nerve endings associated with a muscle spindle?

1. ____________________
2. ____________________

Exercise 10: Responses and Adaptation of Skeletal Muscle to Exercise Training

The soreness associated with muscular pain or discomfort that occurs 16–24 hours after a workout is termed ________________________.

The primary cause of ___________ is associated with:

1. ________________________
2. ________________________
3. ________________________

Which types of muscle actions are most likely to stimulate DOMS? What does this type of muscle action do that causes this to occur?

What are the effects of using NSAIDs on the occurrence of DOMS? Is it wise to use NSAIDs for a long period of time?

Describe what a satellite cell is and its location in relation to the sarcolemma and the basement membrane.

Which type of muscle fiber seems to have a greater density of satellite cells? Why might this be?

How are satellite cells activated and what happens to them in order to allow the formation of a myotube?

Endurance Exercise Adaptations

Chronic endurance training results in a(n) __________ in the number and the size of the mitochondria in skeletal muscle.

What two major enzymes associated with oxidative metabolism are increased with chronic endurance training?

1. ________________________

2. ________________________

Resistance Training Adaptations

The vast majority of the initial training adaptations to resistance training are neural. What are two adaptations to the nervous system that contribute to these adaptations?

1. ____

2. ____

What is the primary factor that accounts for the long-term adaptations associated with resistance training?

Muscle hypertrophy occurs when protein __________ outweighs protein ________.

Resistance training causes acute increases in protein __________ and long-term increases in protein _________.

Type ______ fibers have a greater potential to go through hypertrophy than type _____ fibers.

An increase in the number of muscle fibers is termed ___________________.

A shift of type _______ to type_______ fibers can occur as a result of a heavy strength-training regime.

Generally, no literature has suggested a shift from type _______ to type _______ fibers as an adaptation to a resistance-training regime.

Sprint Training Adaptations

Explain which energy systems provide energy for the performance of sprint exercise. What happens when multiple repetitions of sprint exercise are performed and sprint duration is increased or rest intervals are shortened between each bout of sprinting?

What are four glycolytic enzymes that have been shown to be up-regulated in response to sprint training?

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Sprint training can ______ the activity of oxidative enzymes, allowing for conditioning effects for strength/power athletes as aerobic training _______ training-induced strength and power adaptations.

Explain in detail the three possible adaptations to skeletal muscle that can occur in response to sprint training.

1. ____________________:
2. ____________________:
3. ____________________:

Adaptations to Concurrent Strength and Endurance Training

What are three factors that seem to be compromised in strength/power athletes in response to concurrent strength and endurance training?

1. ____________________________
2. ____________________________
3. ____________________________

Explain how including a resistance training program in the training practices of endurance athletes might result in improvements in endurance performance.

Review Test

1. Why is the neuromuscular junction important in muscle action?
   a. It transmits the nerve impulse
   b. It connects with special stretch sensors
   c. It detects minute changes in muscle fiber length
   d. It delays the nerve impulse transmission

2. Which of the following is not a correct statement about the sliding-filament model of muscle contraction?
   a. A muscle shortens or lengthens because the thick and thin filaments slide past each other
   b. Actin cross-bridges detach from the myosin filaments with energy from ATP hydrolysis
   c. The thick and thin filaments do not change length
   d. None of these statements is incorrect

3. When force applied to the muscle equals force generated by a muscle, you have a(n) ______________ muscle action.
   a. Eccentric
   b. Isokinetic
   c. Isometric
   d. Concentric

4. ____________ binds with calcium allowing for the transformational change of tropomyosin.
   a. Troponin I (Tn-I)
   b. Troponin C (Tn-C)
   c. Troponin T (Tn-T)
   d. Troponin G (Tn-G)

5. Covers actin and prevents contraction during relaxation:
   a. G-actin
   b. Myosin head
   c. Troponin C
   d. Tropomyosin
   e. Troponin T

6. Is an elastic component, which attaches at the M line and the Z disk:
   a. Titin
   b. α-actinin
   c. Desmin
   d. I band
   e. F actin
   f. Myomesin

7. The Z line is primarily composed of:
   a. Titin
   b. α-actinin
   c. Desmin
   d. I band
   e. F actin
   f. Myomesin

8. Which of the following terms represents a repeating pattern of two vesicles and a T tubule in each Z region?
   a. Cytoskeleton
   b. M-bridges
   c. T tubule system
   d. Triad

9. Place the following events in order:
   i) The ryanodine receptor is activated by the DHPR
   ii) ca^{2+} is released from the terminal cisternae
   iii) DHPR is activated
   iv) Acetylcholine binds with membrane receptor
   v) ca^{2+} binds with troponin c

   a. iv, i, ii, iii, v
   b. v, ii, iii, i, iv
   c. iv, iii, i, ii, v
   d. v, iii, ii, i, iv

10. Type I fibers tend to have larger and more complex sarcoplasmic reticulums.
    a. True
    b. False

11. The layer of connective tissue that surrounds the outside of skeletal muscle (i.e., just below the fascia) is called the:
    a. Epimysium
    b. Perimysium
    c. Endomysium
    d. None of the above are correct

12. The two principal contractile proteins found in skeletal muscle are:
    a. Actin and troponin
    b. Actin and myosin
    c. Troponin and tropomyosin
    d. Myosin and tropomyosin

13. Fast-twitch fibers contain:
    a. A relatively large number of mitochondria and low ATPase activity
    b. A relatively small number of mitochondria and low ATPase activity
    c. A relatively small number of mitochondria and high ATPase activity
    d. None of the above are correct

14. Successful endurance athletes generally possess:
    a. A high percentage of slow-twitch fibers
    b. A high percentage of intermediate fibers
    c. A high percentage of fast-twitch fibers
    d. An equal percentage of slow-twitch and fast-twitch fibers

15. Which of these consists of the basic repeating unit between two Z lines and makes up the functional unit of the skeletal muscle?
    a. Z band
    b. Myofibrils
    c. Filaments
    d. Sarcomere

16. At any given velocity of movement, the peak force is greater in muscles that contain a high percentage of type II fibers when compared with muscles that possess predominantly type I fibers.
    a. True
    b. False

17. The Golgi tendon organs monitor:
    a. Tension produced by muscular contraction
    b. The length of muscle
    c. The concentration of sodium ions in the sarcoplasm
    d. The position of joints during movement

18. Type IIb fibers:
    a. Contain a high concentration of anaerobic enzymes
    b. Are very energy efficient
    c. Have high specific tension
    d. a and c only

19. Muscle spindles provide sensory information relative to:
    a. The amount of force generated by muscle during a contraction
    b. The length of muscle
    c. The amount of energy expended during a contraction
    d. None of the above are correct

20. The thin muscle cells located within the muscle spindle are called:
    a. Extrafusal fibers
    b. Gamma fibers
    c. Intrafusal fibers
    d. None of the above are correct

Review of Terminology

Introduction	**Muscle Contractile and Regulatory Proteins**	**Muscle Fiber Architecture**
Hypertrophy	A Band	Bipennate
Skeletal Muscle	Actin	Contraction
	f-Actin	Depolarization
Skeletal Muscle Fiber	g-Actin	Distal
Dihydropyridine Receptor	Globular Head	Fusiform
Mitochondria	H Zone	Fusiform Muscle
Myofibrils	I Band	Inscriptions
Na^+-K^+ ATPase Pump	Myosin	Muscle Cell
Neuromuscular Junction	Myosin Heavy Chain	Muscle Fiber
Ryanodine Receptor	Myosin Light Chain	Myofiber
Sarcolemma	Myosin Cross Bridge	Parallel Arranged Fiber
Sarcomere	Power Stroke	Pennation
Sarcoplasm	Tn-Calcium	Proximal
Sarcoplasmic Reticulum	Tn-Inhibitory	Serially Arranged Fiber
Terminal Cisternae	Tn-T	Unipennate
Z Lines/Z Disks	Tropomyosin	
α-Actinin	Tropomyosin Shift	**Skeletal Muscle Actions**
	Troponin	ATPase
Connective Layers		Concentric Muscle Action
Basal Lamina	**Classification of Muscle Fibers**	Contraction
Endomysium	FF	Dynamic Muscle Action
Epimysium	FG Fibers	Eccentric Muscle Action

Fasciculi	FOG Fibers	Excitation Coupling
Myotendinous Junction	FR	Isometric
Perimysium	MHC I	Muscle Action
Basal Lamina	MHC IIa	Plyometric Muscle Action
Endomysium	MHC IIx	
Epimysium	S	**Regulation of Muscle Force Production**
Fasciculi	SO Fibers	All-or-None Principle
Myotendinous Junction	Type I	Motor Unit Recruitment
Perimysium	Type II	Rate Coding
		Rate of Force Development
The Cytoskeleton	**Factors Determining Strength**	Summation
C Stripes	Force	Synchronization
Desmin	Velocity	Twitch
Dystrophin	Power	α-Motor Neuron
M Line		
Nebulin		
Titin		
Muscular Fatigue	**Sensory Receptors**	**Adaption to Endurance Training**
Central Fatigue	Chemoreceptor	Ablation
Fatigue	Free Nerve Ending	Hyperplasia
Peripheral Fatigue	Golgi Tendon Organ	
	Mechanoreceptors	**Adaption to Sprint Training**
Muscle Satellite Cells	Muscle Spindle	Phosphofructokinase
Mitosis	Nociceptor	
Quiescent	Proprioception	
Mitosis	Thermoreceptor	

Important Abbreviations

ACh	MLC
ADP	Na^{+}
ATP	NSAIDs
ATP-PC	n-T
Ca^{2+}	PCr
DOMS	Pi
FF	S
FG	SERCA
FOG	SO
FR	Tn
GTO	Tn-C
K^{+}	Tn-I
L_0	Tn-T
MHC	V max

3
The Endocrinology of Resistance Exercise and Training

Objectives

On completion of this chapter, you will be able to:

1. Describe the basic relationship between exercise training and the endocrine system.
2. Understand the role of testosterone and how acute and chronic resistance training affects testosterone concentrations.
3. Describe the factors that affect the androgen receptor ability to induce muscular changes.
4. Explain the effect of carbohydrate/protein supplementation on the hormonal responses to a resistance training bout.
5. Understand the effects of resistance training on luteinizing hormone, sex hormone binding globulin.
6. Discuss the effects of supplementation with testosterone precursors.
7. Describe the acute and chronic growth hormone adaptations associated with resistance training.
8. Describe the resistance training factors that are associated with alterations in growth hormone concentrations.
9. Discuss the acute and chronic effects of resistance training on glucocorticoid release.
10. Discuss the importance of the testosterone/cortisol ratio.
11. Understand the effects of acute and chronic resistance training on insulin-like growth factors.
12. Explain the effects of resistance training and carbohydrate and protein supplements on insulin release.
13. Discuss the acute and chronic effects of resistance training on catecholamines, β-endorphins, thyroid hormones, leptin, peptide F, and fluid regulatory hormones.
14. Differentiate between overtraining and overreaching.
15. Describe the hormonal effects of short- and long-term detraining.

Learning Exercises

Exercise 1: Basic Introductory to Neuroendocrine Physiology

What are the four outcomes that can be altered in response to training in terms of acute and chronic physiologic adaptations?

1.

2.

3.

4.

What are four potential stimulators of neuroendocrine responses?

1.

2.

3.

4.

What are the three fundamental concepts associated with progression in a resistance-training program?

1.

2.

3.

What are the four general classifications of endocrine adaptations to resistance training?

1.

2.

3.

4.

Exercise 2: Testosterone

What are three factors that have been suggested to stimulate increases in testosterone levels?

1.

2.

3.

Testosterone seems to have an impact on force-production capacity. What two factors associated with testosterone might contribute to this phenomenon? Give examples of the potential contributors.

1.

2.

Explain what the "free hormone" hypothesis is and how both free and total testosterone relate to each other.

The increases of free testosterone associated with an acute bout of resistance training are greater in __________ than _____________ men.

Explain the effects of chronic resistance training on the acute hormonal responses to resistance training seen in both men and women. Make sure to differentiate among elderly, middle age, and young of both sexes.

What are five factors that seem to influence the magnitude of testosterone-induced increases in response to acute bouts of resistance training?

1.

2.

3.

4.

5.

Large muscle mass exercises seem to induce _______ increases in testosterone concentrations when compared with small mass exercises.

What are three examples of large mass exercises that have been shown to stimulate large increases in testosterone?

1.

2.

3.

Which exercises should be performed first: large or small muscle mass exercises?

If repetitions are held constant and intensity of exercise is increased, a(n) __________ in testosterone is noted.

If intensity is held constant and repetitions completed are increased, a(n) ________ in testosterone is noted.

The higher the glycolytic activity of the training bout, the ________ the increase in testosterone.

Explain the interaction between testosterone responses to resistance training and dietary intake of carbohydrate + protein supplements.

When heavy loading or increases in training volume are encountered, resting testosterone levels can be significantly ____________.

What are four factors that impact the relationship between androgen receptors and known androgen-induced responses?

1.

2.

3.

4.

Explain the relationship between androgen receptors and hypertrophy.

Explain the relationship between baseline androgen receptor content and potential resistance-training-induced alterations in strength.

What are the effects of large-volume, resistance-training programs on androgen receptor content of muscle? What might explain this relationship?

Consuming a carbohydrate/protein beverage before and after training can ________ the high-volume, resistance-training-induced _____ of androgen receptors.

Where is luteinizing hormone secreted?

What does luteinizing hormone regulate?

Describe the relationship among luteinizing hormone, training volume, and training intensity.

Name seven testosterone precursors that have been investigated in the scientific literature:

1.

2.

3.

4.

5.

6.

7.

What are the effects associated with the consumption of low dosages (50–100 mg/day) of prohormones in young, healthy men?

1. Testosterone concentration: ___________
2. Dehydroepiandrosterone: ___________
3. Androstenedione: ___________
4. Luteinizing hormone: ___________
5. Esterone: ___________
6. Estradiol: ___________
7. High density lipoproteins: ___________

What are the effects of low-dose supplementation (50–100 mg/day) of prohormones in postmenopausal women?

Are the effects of higher-dosage supplementation regimes any different than lower-dosage protocols?

Explain the effects of chronic resistance training on the concentrations of androstenedione, DHEA, and DHEA sulfate in men, women, resistance-, and endurance-training athletes.

What is the role of sex hormone binding globulin (SHBG) in influencing 1) the binding capacity of testosterone, and 2) the magnitude of free testosterone availability?

Exercise 3: Growth Hormone

Growth hormone is released from the acidophilic cells of the ____________.

What are the four isoforms of growth hormone and how are they different?

1.

2.

3.

4.

Resistance training has been primarily shown to result in acute _________ in growth hormone.

Women have significantly _________ resting growth hormone levels than men.

Post-resistance-training growth hormone responses are ________ when comparing men and women.

What are eight factors that can affect the magnitude of growth hormone release?

1.

2.

3.

4.

5.

6.

7.

8.

Explain the relationship between blood lactate concentrations and growth hormone release.

What are four factors that have been suggested to influence growth hormone release?

1.

2.

3.

4.

How does aging effect the acute growth hormone responses to resistance training and what happens to this ability when elderly individuals undertake chronic resistance-training programs?

Chronic long-term resistance training __________ resting concentrations of growth hormone.

Acute elevations in growth hormone that are a result of exercise have been highly correlated to _________ and __________ muscle fiber hypertrophy.

Explain the role and origin of GH-specific binding proteins (GHBPs).

Exercise 4: Cortisol

The primary glucocorticoid released from the _______________ in response to stress is ___________, which accounts for ~95% of all glucocorticoid activity.

What are the three primary catabolic functions of cortisol?

1.

2.

3.

The catabolic effects associated with cortisol are _________ in fast-twitch muscle when directly compared with slow-twitch muscle.

________ percent of cortisol circulating throughout the body is in the bound form. What are the two binding proteins that accomplish this and what percentage of cortisol is bound to them?

1. (%)

2. (%)

Cortisol attempts to spare ___________ by shifting to the metabolism of other compounds.

Acute bouts of resistance training have the ability to increase:

1.

2.

Endurance athletes might have a ___________ cortisol response compared with resistance-training men while performing the same resistance-training protocol.

What two things have serum cortisol levels been shown to have a positive correlation with?

1.

2.

What four characteristics of a metabolically demanding resistance-training bout can stimulate the greatest lactate and cortisol responses?

1.

2.

3.

4.

Explain the effects of consuming a carbohydrate beverage on acute cortisol responses to a resistance-training bout.

Explain the effects of long-term resistance training on resting cortisol.

What are two ways that the anabolic status can be represented?

1.

2.

The T/C ratio has been suggested to be positively related to _________.

What two things regulate glucocorticoid receptors?

1.

2.

Participation in long-term resistance training might _______ the glucocorticoid receptor content.

What benefit would be created by down-regulating glucocorticoid receptors?

Explain what insulinlike growth factor (IGF) is, where it is synthesized, and what the difference is between IGF-1 and IGF-2.

What is the potential role of postexercise increases in IGF?

What are the effects of short-term resistance training or overreaching on IGF-1?

Men or women who have participated in chronic resistance training, especially high-volume training, for long periods of time have ________ resting IGF-1 concentrations.

What two factors probably affect the chronic adaptations associated with IGF-1?

1.

2.

Exercise 5: Insulin-like Growth Factor

Insulin-like growth factor 1 (IGF-1) seems to have both _______ and ______ functions within skeletal muscle.

What are the two independent nonhepatic isoforms of IGF that have been identified in skeletal muscle?

1.

2.

What two things do the two nonhepatic isoforms seem to do?

1.

2.

What do IGF binding proteins (IGFBPs) seem to do?

Explain the effects of acute bouts of resistance training on IGFBP.

Exercise 6: Insulin

If blood glucose levels are increased, insulin levels are ________________.

If insulin levels are increased and amino acids are available, protein synthesis will ___________.

Without ingestion of carbohydrates and or proteins before, during, or after an exercise bout, you would expect insulin levels to ____________.

Insulin levels are affected more by __________ than by ____________.

Explain why it might be beneficial to ingest a carbohydrate and protein beverage before, during, and after an acute bout of resistance training.

Exercise 7: Catecholamines

What are the three main catecholamines?

1.

2.

3.

What four training factors impact the release of catecholamines in response to an acute bout of resistance training?

1.

2.

3.

4.

Exercise 8: Other Important Hormones

Explain why some resistance training studies report increases, no change, or reductions in β-endorphins in response to acute training bouts.

What resistance-training factors have been associated with alterations in β- endorphins?

1.

2.

3.

4.

β-Endorphins have been suggested to be highly correlated to __________.

What type of training programs seem to elicit the greatest increaes in plasma β-endorphins levels?

What are the two thyroid hormones?

1.

2.

What are the six fluid regulatory hormones that have been shown to be increased in response to exercise?

1.

2.

3.

4.

5.

6.

What factors seem to modulate the release of fluid regulatory hormones?

1.

2

3.

What is leptin, where does it come from, and what does it do?

What do high levels of energy expenditure do to leptin concentrations?

Explain in detail how leptin reduces steroidogenesis.

Men who are obese tend to have lower:

1.

2.

3.

4.

Explain what peptide F is and where it is secreted from.

Peptide F has been shown to be __________ for 4 hours after the completion of an acute bout of heavy-resistance training.

Exercise 9: Overtraining

Overtraining can be stimulated by:

1.

2.

Overtraining results in _________ in performance.

Compare and contrast overreaching and overtraining.

Repeated overreaching has been shown to result in _________ testosterone and _____ IGF-1 concentrations in as little as 1–2 weeks.

Overtraining has been shown to result in:

1.

2.

3.

4.

When comparing total and free testosterone, ________ is the most sensitive marker of overtraining.

Compare and contrast the hormonal alterations associated with intensity-based overtraining to volume-based overtraining.

Exercise 10: Detraining

What is the definition of detraining?

What hormonal alterations might you expect when looking at short-term (2 weeks) and long-term (6–8 weeks) detraining?

Exercise 11: Circadian Patterns

What is a circadian pattern?

Does resistance training alter the hormonal circadian patterns?

The greatest testosterone levels are noted in ___________.

Explain the nocturnal hormonal responses that might occur after an acute resistance-training bout.

Exercise 12: Concurrent Strength and Endurance Training

What are the effects of combining concurrent strength and endurance training on the ability to exert maximal force and power?

Are the effects of combined training associated with adverse hormonal changes?

Review Test

1. The effect of an acute bout of resistance training on circulating testosterone levels:
   a. Increased circulating levels
   b. Decreased circulating levels
   c. No effect on circulating levels

2. Increases in testosterone have been suggested to occur as a result of:
   a. Increases in plasma volume
   b. Lactate stimulated secretion
   c. Adrenergic stimulation
   d. a and b
   e. b and c

3. Testosterone has been suggested to be affected by several training factors. Which of the following training factors would affect testosterone concentrations?
   a. The training experience of the athlete
   b. The individual's absolute level of muscular strength
   c. The intensity of the training program
   d. a and b
   e. b and c
   f. a and c

4. Performing small muscle mass exercises before large muscle mass exercises might produce significant increases in testosterone that could magnify the adaptations resulting from the larger muscle mass exercises.
   a. True
   b. False

5. If intensity is held constant, greater testosterone concentrations are noted with increases in the number of exercise sets encountered.
   a. True
   b. False

6. The ingestion of carbohydrate and protein supplements has been shown to magnify the testosterone response to a resistance-training bout.
   a. True
   b. False

7. High-volume resistance-training sessions have the potential to __________ the skeletal muscle androgen content.
   a. Up-regulate
   b. Down regulate
   c. Do nothing to

8. The consumption of a carbohydrate/protein supplement seems to attenuate the down-regulation of androgen receptors.
   a. True
   b. False

9. The effect of an acute bout of resistance training on leuteinizing hormone concentrations:
   a. Increased
   b. Decreased
   c. Unaffected

10. In young, healthy men, DHEA has been shown to increase circulating testosterone levels.
    a. True
    b. False

11. Men tend to have significantly higher resting growth hormone concentrations than women.
    a. True
    b. False

12. All of the following result in significant increases in circulating growth hormone levels except:
    a. High levels of lactic acid
    b. Low levels of acidosis
    c. Long rest intervals
    d. Large muscle mass exercise
    e. a and d
    f. b and c

13. All of the following are functions of cortisol except:
    a. Increases protein synthesis
    b. Stimulates lipolysis
    c. Stimulates glycogenolysis
    d. Increases glucose uptake

14. The highest cortisol responses are caused by low-volume, high-intensity bouts separated by long rest intervals.
    a. True
    b. False

15. Chronic resistance training might _______________ glucocorticoid receptor content.
    a. Up-regulate
    b. Down-regulate
    c. Increase
    d. None of the above

16. Insulin-like growth factor is produced in what tissue?
    a. Muscle
    b. Adipose tissue
    c. Liver
    d. Kidney
    e. Bone

17. All of the following are long-term effects of chronic resistance training of insulin-like growth factor 1 (IGF-1) except:
    a. Increases in trained men when compared with untrained men
    b. Increases in trained women when compared with untrained women
    c. Increases in untrained men when compared with trained men
    d. Increases in untrained women when compared with untrained women
    e. a and b
    f. c and d

18. All of the following factors increase insulin release except:
    a. High levels of blood glucose
    b. Acute bouts of resistance training
    c. Carbohydrate and protein supplements
    d. a and b
    e. b and c

19. The highest increases in circulating β-endorphin levels have been associated with:
    a. Low-volume resistance-training programs with short rest intervals
    b. High-volume resistance-training programs with long rest intervals
    c. Low-volume resistance-training programs with high loads
    d. High-volume resistance-training programs with short rest intervals

20. Overreaching has been shown to stimulate all of the following except:
    a. Depressed resting testosterone levels
    b. Suppression of the testosterone/cortisol ratio
    c. Increases in circulating IGF-1
    d. Reductions in the free androgen index

Review of Terminology

Introduction	**Testosterone**	**Catecholamines**
Diurnal	19-Norandrostenediol	Dopamine
Homeostatic	19-Norandrostenedione	Epinephrine
Hypertrophy	1-Androstene-3β-diol	Norepinephrine
Neuroendocrine	4-Androstendione	Psychophysiology
Power	4-Androstenediol	
Progressive Overload	5-Androstenediol	**Other Hormones**
Specificity	Adrenergic	β-Endorphins
	Androgen Receptors	Aldosterone
Growth Hormone	Catabolic	Angiotensin II
Growth Hormone Binding Protein	Dehydroepiandrosterone	Arterial Peptide
Hypoxia	Estradiol	Cytochrome P450
Insulin-like Growth Factor	Estrone	Leptin
Kilodalton	Free Testosterone	Peptide F
Polypeptide	Glycolytic	Proenkephalin Fragments
Type I	High Density Lipoprotein	Renin
Type II	Leydig Cells	Steroidogenesis
	Luteinizing Hormone	Steroidogenic Acute Regulatory Protein
Cortisol	Myonuclei	Steroidogenic Factor 1
Adenosine Triphosphate	Neurotransmitters	Thyroid Hormones
Adrenocorticotropic Hormone	Prohormone	Thyroid-Stimulating Hormone
Albumin	Sex Hormone-Binding Globulin	Thyroxine
Anabolic	Total Testosterone	Triiodothyronine
Catabolic		Vasopressin
Corticosteroid-Binding Protein	**Insulinlike Growth Factor**	
Eccentric	Autocrine	
Glucocorticoid	Insulin	
Glycogen	Insulin-like Growth Factor Binding Protein	
Lactate	Mechano Growth Factor	
Lipolysis	Overreaching	
	Paracrine	
	Polypeptide	

Important Abbreviations

ACTH	kD
AR	LH
ATP	MGF
DHEA	mRNA
GH	RM
GHBP	SF-1
HDL	SHBG
IGF	StAR
IGFBP	T/C
IGFBP-3	T3
IGF-1	T4
IGF-2	TSH

4
Cardiovascular and Pulmonary Responses to Exercise

Objectives

On the completion of this chapter, you will be able to:

1. Explain the steps associated with ventilation and pulmonary circulation.
2. Describe the difference between ventilation during resting and exercise conditions.
3. Understand the consequences of the Valsalva maneuver.
4. Describe the membranes that must be crossed in order to get oxygen from the lungs into the blood.
5. Explain the blood-carrying capacity and how erythropoietin affects this capacity.
6. Understand the steps associated with moving blood through the systemic circulation.
7. Describe the acute and chronic effects of endurance and resistance training on the cardiovascular system.
8. Explain the differences in VO_2 max between men and women and athletes in a variety of sports.
9. Understand the effects of different genetic characteristics on endurance and resistance training performance.

Learning Exercises

Exercise 1: Understanding the Cardiovascular and Pulmonary Responses

What are the five components associated with oxygen transport?

1.

2.

3.

4.

5.

Define the following terms:

1. Ventilation:

2. Valsalva maneuver:

When the size of the pulmonary cavity is increased, environmental air rushes _______, and when the size of the pulmonary cavity is decreased, air is forced _______ of the airways.

At rest, what two muscles contract to cause an increase in the size of the pulmonary cavity?

1.

2.

Explain the process of inhalation and exhalation. In this explanation, compare and contrast how resting and exercise differ.

During maximal exercise, what muscles contract to enhance expiration?

1.

2.

What are the two factors that contribute to an increase in ventilation during exercise?

1.

2.

Explain what the Valsalva maneuver is and what effects it causes.

Compare and contrast the oxygen and carbon dioxide content of alveolar air and pulmonary blood.

What are the five barriers that oxygen must transverse at the alveoli during the ventilation process?

1.

2.

3.

4.

5.

When asthma occurs, there is an obstruction of the airways; where does this occur, and what is the consequence of this occurrence?

At rest, blood passes through the lungs in a time frame of approximately ________, whereas during exercise this can be decreased to ________.

The vast majority of the ________ $mL \cdot O_2 \cdot 100\ mL^{-1}$ carried by blood is carried bound to ________.

Compare and contrast the hemoglobin concentrations of both men and women. Make sure to include ranges of hemoglobin and hematocrit.

When athletes use erythropoietin, what possible positive and negative outcomes can occur?

What does erythropoietin stimulate?

Place the following events in order (1 = first):

1. ________ Arteriovenous valve opens and blood moves into the left ventricle
2. ________ Atrium contracts
3. ________ An increase in left ventricle pressure occurs
4. ________ Blood returns to the left ventricle from the pulmonary circulation
5. ________ An increase in atrial pressure closes the pulmonary valve
6. ________ Left ventricle contracts
7. ________ Aortic valve opens and the arteriovenous valve closes
8. ________ A volume of blood is pumped into the aorta before the AV valve closes again

Where does the systemic circulation carry blood?

The ________ are encircled by smooth muscle, which can be contracted in order to restrict blood flow.

The ability to process oxygen in the muscle is directly related to the ________ volume.

Type ________ fibers have higher aerobic enzyme activity than type ________ muscle fibers.

________ carries oxygen in the blood, whereas ________ carries oxygen in the muscle.

Exercise 2: Cardiovascular Responses to Acute and Chronic Exercise

What are the four immediate changes that occur to the cardiovascular and pulmonary systems when transitioning from rest to exercise?

1.
2.
3.
4.

What are the six chronic adaptations to repeated bouts of exercise?

1.
2.
3.
4.
5.
6.

Ventilation at rest is approximately _______.

Ventilation during maximal exercise can increase to _______ and in highly trained athletes approach _______.

Explain why ventilation does not normally limit exercise performance.

During maximal exercise with highly trained aerobic athletes, the transit time for blood to pass through the lungs might be too _______ for complete O_2 saturation to occur.

The _______ occurs when breathing or ventilation increases in a curvilinear manner. Typically, this occurs somewhere between _______% of VO_2 max.

If John is 25 years old, what would his age-predicted maximum heart rate be?

At what percent of VO_2 max would you expect to see no more increases in stroke volume in response to the exercise bout?

What are three possible mechanisms that might explain why one might not see a plateau in elite endurance athletes at submaximal exercise intensities?

1.
2.
3.

What is the formula for cardiac output?

$$\quad = \quad \times \quad$$

What is the approximate cardiac output for:

1. Untrained individual during resting conditions: ________________
2. Highly trained individual during resting conditions: _____________
3. Untrained individual during maximum exercise conditions: _____________
4. Highly trained individual during maximum exercise conditions: _____________

Cardiac output increases proportionally to _____________ at about a 6:1 ratio for both trained and untrained individuals.

Explain what happens to blood flow when transitioning from rest to exercise.

What does hot weather and dehydration do to blood flow, stroke volume, cardiac output, and oxygen delivery to muscle?

Exercise 3: VO_2 max Testing

What does a VO_2 max represent and how is it typically expressed?

How is a VO_2 max tested? (Note: give a general description).

What are five factors that explain why women have VO_2 max values that are 5%–10% lower than men?

1.
2.
3.
4.
5.

Exercise 4: Resting Cardiopulmonary Function: Effects of Training

	Endurance training exercise effects
Resting conditions	
Heart rate	
Cardiac output	
Blood volume	
Plasma volume	
Arterial blood pressure	
Heart chamber size	
Maximal exercise conditions	
Stroke volume	
Heart rate	
Arteriovenous difference	
Note: ⇑ = increase, ⇓ = decrease, ⇔ = unaltered.	

Compare maximal cardiac output of elite endurance athletes and cardiac patients.

What are the general muscle adaptation differences between a low-repetition, heavy-weight, resistance-training regime and a high-repetition, low-weight, resistance-training regime?

What are the effects of chronic resistance training on the following?

1. Heart wall thickness: ______________
2. Cardiac mass: ______________
3. Muscle aerobic activity: ______________
4. Muscle capillarity: ______________

Fill in the following table:

	Sedentary untrained	**Resistance trained**	**Endurance trained**
At rest			
Heart rate			⇓
Stroke volume			
Cardiac output			⇔
VO_2			
Systolic blood pressure		⇔⇓	
Diastolic blood pressure			
Maximal exercise			
Heart rate	200 beats·min^{-1}	⇔	
Stroke volume			
Cardiac output			
VO_2			
Systolic blood pressure			⇔
Diastolic blood pressure	75 mm Hg	⇔	

Note: ⇑ = increase, ⇓ = decrease, ⇔ = unaltered.
Numbers are for a man between 18–45 years, height = 175 cm, weight = 70 kg, body fat = 20%.

Fill in the following table:

	Aerobic athlete	**Resistance-trained athlete**
LVV (mL)		
LVIDd (mm)		
SV (mL)		
LVWT (mm)		
Septal thickness (mm)		
LV mass (g)		

Note: ⇑ = increase, ⇓ = decrease, ⇔ = unaltered.

Define the following terms:

1. LVIDd:
2. LVV:
3. LVWT:

Differentiate between concentric and eccentric hypertrophy.

Fill in the following table:

	Endurance trained	Resistance trained
Energy system enzyme capacity		
Phosphagen		
Short-term glycolysis		
Aerobic		
Mitochondrial volume		
Capillary-to-muscle fiber ratio		
Note: ⇑ = increase, ⇓ = decrease, ⇔ = unaltered.		

Explain the genetic determinants of endurance performance. Include in this explanation a discussion about the angiotensin-converting enzyme and the different alleles.

Review Test

1. Cardiac output is calculated as:
   a. Heart rate/stroke volume
   b. Stroke volume/heart rate
   c. Heart rate × stroke volume
   d. None of the above

2. Many exercise physiologists suggest the best single indicator of physical fitness is:
   a. Resting heart rate
   b. VO_2 max
   c. Resting blood pressure
   d. Maximal heart rate

3. During exercise, exhalation is accomplished by:
   a. Contraction of the diaphragm and the external intercostals
   b. Contraction of the internal intercostals and the diaphragm
   c. Contraction of the abdominal muscles and the external intercostals
   d. Contraction of the internal intercostals and the abdominal muscles

4. The Valsalva maneuver is:
   a. A breath-holding technique
   b. A series of rapid deep breaths
   c. A maximal exhalation
   d. A series of slow, shallow breaths

5. During intense exercise, blood could pass through the lungs in as little as ________.
   a. 1.0 s
   b. 0.8 s
   c. 0.4 s
   d. 2.0 s

6. The main factor contributing to the difference in VO_2 max between men and women is that women have:
   a. Lower hemoglobin concentrations than men
   b. Greater plasma volume than men
   c. Larger hearts than men
   d. Higher hematocrit levels than men

7. All of the following would happen if a cyclist were to take EPO **EXCEPT**:
   a. The cyclist would experience a significant increase in red blood cell count
   b. The cyclist would experience increased muscular hypertrophy
   c. When exercising in a hot and humid environment, the cyclist would experience an increase in blood viscosity
   d. The cyclist would experience a greater risk for a heart attack while performing intense exercise in a hot environment

8. All of the following are responses to chronic resistance training except:
   a. A thickening of the heart wall
   b. An increase in mass
   c. An increase in capillary density
   d. An increase in resting cardiac output
   e. a and b
   f. c and d

9. Ventilation of an elite athlete can approach ________ during maximal exercise.
   a. 6 $L{\cdot}min^{-1}$
   b. 20 $L{\cdot}min^{-1}$
   c. 150 $L{\cdot}min^{-1}$
   d. 200 $L{\cdot}min^{-1}$

10. Ventilation is a primary limiter for aerobic endurance performance.
    a. True
    b. False

11. All of the following increase with increasing exercise intensity except:
    a. Heart rate
    b. VO_2
    c. Diastolic blood pressure
    d. Cardiac output

12. The resting cardiac output for a highly trained marathon runner would be approximately:
    a. 40 $L{\cdot}min^{-1}$
    b. 5 $L{\cdot}min^{-1}$
    c. 20 $L{\cdot}min^{-1}$
    d. None of the above

13. During intense aerobic exercise in a hot environment, part of the cardiac output is distributed to the skin in order to cool the body.
    a. True
    b. False

14. The average VO_2 max for an untrained male is approximately:
    a. 75 $mL{\cdot}kg^{-1}min^{-1}$
    b. 59 $mL{\cdot}kg^{-1}min^{-1}$
    c. 42 $mL{\cdot}kg^{-1}min^{-1}$
    d. 25 $mL{\cdot}kg^{-1}min^{-1}$

15. All of the following are adaptations to chronic aerobic training **EXCEPT**:
    a. Decreased resting cardiac output
    b. Increase in resting stroke volume
    c. Decrease in resting heart rate
    d. a and b
    e. b and c
    f. None of the above

16. All of the following are adaptations to chronic resistance training **EXCEPT**:
    a. Increase in systolic blood pressure during maximal exercise
    b. No change in diastolic blood pressure during maximal exercise
    c. A slight increase in VO_2 during maximal exercise
    d. An increase in maximal heart rate
    e. a and d
    f. b and c

17. Chronic endurance training can result in a 20%–30% increase in left ventricular wall thickness.
    a. True
    b. False

18. Athletes who demonstrate the I/I genotype seem to be better at endurance exercise than those with the D/D genotype.
    a. True
    b. False

19. Place the following steps associated with systemic circulation in order:
    i. Left ventricle quickly contracts
    ii. The atrium contracts
    iii. Oxygenated blood enters the left atrium via the pulmonary vein
    iv. There is an increase in left ventricular pressure
    v. Increasing atrial pressure closes the pulmonary valve and opens the AV valve
    vi. Blood is pushed into the left ventricle
    vii. A volume of blood exits the heart into the aorta
    viii. The aortic valve opens while the AV valve closes

    a. iii, ii, v, vi, i, iv, viii, vii
    b. iii, v, ii, i, vi, iv, vii, viii
    c. iii, i, v, ii, vi, iv, viii, vii
    d. iii, vi, i, v, ii, iv, viii, vii

20. Place the following barriers that oxygen must transverse in order:
    i. Red blood cell membrane
    ii. Alveolar membrane
    iii. Intravascular fluid space
    iv. Pulmonary capillary membrane
    v. Extravascular fluid space

    a. i, v, iii, ii, iv
    b. ii, v, iv, iii, i
    c. ii, iv, i, v, iii
    d. i, ii, v, iv, iii

Review of Terminology

Understanding Cardiovascular and Pulmonary Responses	**Cardiovascular Responses to Acute and Chronic Exercise**	**VO_2 max Test**
Atrium	Cardiac Output	Carbon Dioxide
Bronchioles	Diastolic Blood Pressure	Oxygen
Capillaries	Heart Rate	Plasma Volume
Diaphragm	Myocardium	
Erythropoietin	O_2 Saturation	**Resting Cardiopulmonary Functions**
Exhalation	Stroke Volume	Arterial Blood Pressure
External Intercostals	Systolic Blood Pressure	Arteriovenous Difference
Hematocrit	Ventilatory Threshold	Capillaries
Hemoglobin		Concentric Hypertrophy
Inhalation		Eccentric Hypertrophy
Intravascular Fluid Space		Heart Rate
Mitochondria		Myocardium
Perfusion		
Pulmonary Capacity		
Pulmonary Circulation		
Pulmonary Valve		
Respiratory Rate		
Systemic Circulation		
Tidal Volume		
Tidal Volume		
Type I		
Type II		
Valsalva Maneuver		
Ventilation		
Ventricle		
VO_2 max		

Important Abbreviations

ACE	LVIDd
BO	LVV
CO_2	LVWT
D	O^2
DBP	SBP
EPO	SV
H_2O	Ve
HR	VO_2 max
I	

5
Molecular Biology of Exercise and Nutrition

Objectives

On the completion of this chapter, you will be able to:

1. Understand the basic steps associated with the flow of genetic information.
2. Explain how genes regulate the adaptive processes associated with exercise.
3. Describe different regulatory proteins and how they activate or inhibit specific signaling pathways.
4. Understand the interaction between a ligand and a receptor complex.
5. Describe how signals are passed through cell membrane to initiate specific signaling pathways.
6. Explain how a polypeptide is initiated.
7. Describe how a polypeptide is translated into a functional protein.
8. Understand how newly synthesized proteins are manipulated.
9. Explain the specific mechanisms associated with the degradation of proteins.
10. Describe specific proteolytic pathways.
11. Understand the balance between anabolism and catabolism.
12. Explain the relationship between anabolic and catabolic hormones and how they relate to protein turnover.

Learning Exercises

Exercise 1: The Central Dogma of Molecular Biology

Genetic information travels from ________ to ________ and ultimately to the ______________ of proteins.

What is DNA and what does it do?

What is the process of transcription and what happens to DNA during this process?

The process whereby proteins are formed in the cytoplasm is termed ___________.

How many different amino acids are utilized in the process of ___________?

In this process, total number of amino acids can be broken into _______ essential and ________ nonessential amino acids.

Explain the central dogma in relation to the premise that one gene encodes for one protein.

Exercise 2: Gene Expression: The Foundation of Physiologic Adaptations to Exercise

Give four examples of regulatory proteins associated with various skeletal-muscle specific genes.

1.

2.

3.

4.

List four of the myogenic regulatory factors that are known transcription factors that bind to DNA sequences and up-regulate gene expression.

1.

2.

3.

4.

What are the two possible mechanisms that regulate a gene?

1.

2.

Give an example of a DNA-binding protein that prevents or blunts the expression of a gene.

Explain the effects of an acute-resistance training bout on the expression of binding proteins. How do these changes affect fast and slow myosin heavy chains?

What occurs when creatine supplementation is combined with heavy resistance training?

Explain what happens when a transcription factor protein binds to the promoter region within a gene.

A ___________ is the molecule that binds to the promoter region of a protein. The combination of the ___________ and the protein forms the ___________ complex.

Give an example of a molecule that binds to an androgen receptor.

Explain the difference between the process involved in binding with a cell membrane receptor or a receptor within the cell.

Exercise 3: Activation of Transcription Factors via Signal Transduction Pathways

What happens if the receptor is found on the cell membrane? What is this pathway called?

Explain the difference between an intercellular kinase enzyme and an intracellular phosphatase enzyme.

What two intermittent signal processes are known as covalent modification?

1.

2.

Draw the insulin signaling pathway.

Explain the events and outcomes associated with the insulin signaling pathway as it relates to blood glucose levels.

Exercise 4: Protein Translation: The Birth of a Polypeptide

What is translation and what does it involve?

What are the three phases associated with translation?

1.

2.

3.

Explain what occurs in each of the three phases of translation.

1. ______________:
2. ______________:
3. ______________:

Exercise 5: Outcome of Protein Translation: Synthesis of a Functional Protein

______________ is a process in which a polypeptide's sequence of attached amino acids is modified in order to allow it to become a fully active protein.

Name and describe the four primary protein structures.

1. ______________:
2. ______________:
3. ______________:
4. ______________:

Name and describe the two categories of secondary structures for proteins.

1. ______________:
2. ______________:

Exercise 6: Molecular Chaperones

What is the role of molecular chaperones?

At which stages do molecular chaperones bind and stabilize proteins?

1.
2.
3.
4.

How are heat shock proteins classified?

What are heat shock proteins, and what do they do?

Which heat shock protein is described as a stress protein, and why is it described this way?

Molecular chaperones interact with unfolded or partially folded protein subunits to stabilize ______________ and facilitate ______________ of protein subunits.

Molecular chaperones do not interact with ______________.

What are three things molecular chaperones do when cellular stress is increased?

1.

2.

3.

Exercise 7: Mechanisms of Protein Degradation

Protein degradation can range between ______% per hour and _______% per hour.

Under what conditions are higher percentages of protein degradation present?

What are the half-lives for:

1. Protein:______________.
2. Regulatory enzymes______________.

What are the two major sites of intracellular proteolysis, and which types of proteins are degraded in each site?

1.

2.

Define and describe the following terms:

1. Protein turnover:
2. Long-lived proteins:
3. Short-lived proteins:

List and describe the three proteolytic systems in skeletal muscles.

1.

2.

3.

Exercise 8: Anabolism Versus Catabolism

Define the following terms:

1. Anabolism:
2. Catabolism:
3. Anabolism/catabolism ratio:

What happens to the anabolism/catabolism ratio when protein synthesis exceeds protein degradation? For example, consider the muscle tissue synthesis to protein catabolism.

What happens to the anabolism/catabolism ratio when protein degradation exceeds protein synthesis?

Give three examples of new cellular material that can be created during anabolism.

1.
2.
3.

Anabolism always requires ______________, whereas catabolism always results in the release of ______________.

Exercise 9: Hormonal Control of Cellular Function

What is a hormone?

What are five regulatory actions that can be associated with hormones?

1.
2.
3.
4.
5.

Define and describe the three major classifications of hormones.

1.

2.

3.

What are the four ways that hormones alter the rates of cellular reactions?

1.

2.

3.

4.

Where do amine and peptide hormones exert their actions?

What is cyclic AMP and what does it do?

What are the three major hormones that have been shown to be activated in response to mechanical overload such as resistance training?

1.

2.

3.

List and describe the actions of these hormones.

1.

2.

3.

Explain the actions of cortisol and how it relates to the other hormones listed above.

Review Test

1. All of the following are examples of transcription factors known to bind DNA sequences at specific sites along the gene's promoter region and produce an up-regulation of gene expression except:
   a. Myogenin
   b. Creatine kinase
   c. MRF-4
   d. Myo-D

2. Single bouts of resistance training have been shown to up-regulate _________ activity.
   a. Myogenin
   b. Id-1
   c. MRF-4
   d. a and b
   e. a and c

3. All of the following are true about DNA except:
   a. DNA can self-replicate in the nucleus of a cell using only one strand of the double helix as a template
   b. DNA codes mRNA in the process called translation
   c. The genetic flow of information goes from DNA to RNA and then through translation of proteins
   d. a and b

4. Creatine supplementation combined with heavy resistance training can up-regulate the expression of fast isoforms of myosin heavy chains.
   a. True
   b. False

5. Which class of membrane-bound receptors has the ability to phosphorylate proteins?
   a. Phosphatase enzymes
   b. Receptor kinase enzymes
   c. Phosphorylase enzymes
   d. Polymerase enzymes

6. The process in which essential and nonessential amino acids are used to synthesize proteins is called:
   a. Translation
   b. Transcription
   c. Replication
   d. Posttranslational modification

7. After proteins are formed, they often need to be modified to function appropriately; this process is called:
   a. Translation
   b. Transcription
   c. Replication
   d. Posttranslational modification

8. The activation of the enzyme RNA polymerase occurs during:
   a. Translation
   b. Transcription
   c. Replication
   d. Posttranslational modification

9. All of the following are associated with covalent modification except:
   a. Dephosphorylation
   b. Phosphorylation
   c. Transcription
   d. a and b

10. What is the process in which DNA codes for mRNA and produces a template?
    a. Translation
    b. Transcription
    c. Replication
    d. Posttranslational modification

11. All of the following are true about the insulin-signaling pathway except:
    a. Insulin binds to glucose and ultimately insulin receptors
    b. The pathway is mediated by levels of glucose in the blood
    c. Binding to insulin receptors results in signal transduction
    d. None of the above

12. The reaction in which the first aminoacyl-transfer of RNA and the mRNA are bound to the ribosome and carries the amino acid methionine is known as ______________
    a. Elongation
    b. Initiation
    c. Termination
    d. Translation

13. During ______________, amino acids are joined together and the ribosome travels down the mRNA.
   a. Elongation
   b. Initiation
   c. Termination
   d. Translation

14. The ______________is the end bearing the residue with the free amino group.
   a. C terminal
   b. N terminal
   c. α-Helix
   d. None of the above

15. The ordered array of amino acids in a protein confers regular conformational forms known as the ______________.
   a. Quaternary structures
   b. Tertiary structures
   c. Secondary structures
   d. Primary structures

16. The complete three-dimensional structure of the polypeptide units for a given protein is the ______________.
   a. Quaternary structure
   b. Tertiary structure
   c. Secondary structure
   d. Primary structure

17. α-Helix structures have two or more different regions of "sheet-like" structures containing at least 5–10 amino acids.
   a. True
   b. False

18. An oligomeric protein is known as a:
   a. Quaternary structure
   b. Tertiary structure
   c. Secondary structure
   d. Primary structure

19. Heat shock protein HSP-72 has a molecular weight of ______________.
   a. 70 kDa
   b. 80 kDa
   c. 72 kDa
   d. 25 kDa

20. Molecular chaperones such as HSP-70 contribute to all of the following except:
    a. Bind and stabilize proteins at the intermediate stages of folding
    b. Bind and stabilize proteins during assembly
    c. Can have their expression increased during situations of low stress
    d. Prevent the formation of misfolded protein structures

Review of Terminology

THE Central Dogma	**Gene Expression**	**Activation and Transcription**
DNA Polymerase	Ligand Receptor Complex	Dephosphorylations
Genome	Myogenic Regulatory Factor	Phosphorylation
Proteome	Myogenin	Signal Transduction Pathway
	Myosin Heavy Chain	Transcription
The Birth of a Polypeptide	Promoter	
Translation	RNA Polymerase	**Outcome of Protein Translation**
		Polypeptides
Molecular Chaperones	**Mechanisms of Intracellular Protein Degradation**	Quaternary Structure
Heat Shock Protein	Anabolism	Tertiary Structure
Oligomeric Proteins	Calpains	Transduction
	Catabolism	
Anabolism and Catabolism	Lysosomal	**Hormonal Control of Cellular Function**
Anabolism		Amine
Catabolism		Cortisol
Proteolysis		Cyclic AMP
		Endocrine System
		Growth Hormone
		Hormone
		Insulinlike Growth Factor
		Nonsteroid Hormone
		Steroid Hormone
		Testosterone

Important Abbreviations

20S	IF4E
DNA	IGF-1
E2	MRF-4
E3	mRNA
GH	myf-5
HSP-70	Myo-D
HSP-72	RNA
Id-1	tRNA

6
Aspects of Overtraining

Objectives

On the completion of this chapter, you will be able to:

1. Differentiate between overreaching and overtraining.
2. Describe the physiologic signs and symptoms of overtraining.
3. Explain the differences between parasympathetic and sympathetic overtraining.
4. Understand the physiologic and psychologic consequences of overtraining.
5. Illustrate the major factors that make up the central fatigue hypothesis.
6. Describe the major components of a needs analysis.
7. Understand the basic components of a periodized training program.
8. Explain the role of glutamine, protein, vitamin C, zinc, and Echinacea as tools for avoiding overtraining.
9. Illustrate the role of sound nutrition in the prevention of overtraining.
10. Conceptualize the role of nutrient timing in the prevention of overtraining.
11. Understand the importance of maintaining appropriate hydration.
12. Describe the dietary carbohydrate, protein, and fat needs of athletes.

Learning Exercises

Exercise 1: Overreaching and Overtraining in Sport and Exercise

Define the following terms:

1. Overreaching:
2. Overtraining:
3. Overtraining syndrome:

Fill in the appropriate information in the table below:

	Theoretical stages for the development of overtraining			
	1st Stage	**2nd Stage**	**3rd Stage**	**4th Stage**
Performance	⇔			
Neural		Altered motor unit Recruitment		
Skeletal muscle				
Metabolic				
Cardiovascular			⇑ Resting HR⇑ Resting BP	
Immune				Sickness and infection
Endocrine				
Psychologic			Mood disturbances	
Note: ⇓ = decrease, ⇑ = increase, ⇔ = no effect.				

Exercise 2: Physiologic Sympathetic and Parasympathetic Overtraining

Define the following terms:

1. Sympathetic overtraining:
2. Parasympathetic overtraining:

______________ overtraining is predominately associated with anaerobic exercise such as resistance training, whereas ______________ overtraining is associated with endurance training.

What are the six possible factors that can result in a performance decrement?

1.

2.

3.

4.

5.

6.

Fill in the markers associated with anaerobic overtraining in the following table:

Variable	**Markers of anaerobic overtraining**
Psychologic effects	
Acute epinephrine and norepinephrine responses	
Performance	

Fill in the following table describing the different factors associated with the markers of aerobic overtraining:

Variable	**Overtraining**	**Variable**	**Overtraining**
Performance	⇓	Cortisol concentration	⇓⇑
Percentage of body fat		Total testosterone concentration	
Maximal oxygen uptake		Total testosterone to cortisol ratio	
Blood pressure		Testosterone to cortisol ratio	
Muscle soreness		Total testosterone to sex hormone-binding globulin	
Muscle glycogen	⇓	Sympathetic tone	⇓
Resting heart rate	⇓⇑	Sympathetic stress response	
Submaximal exercise heart rate		Creatine kinase	
Lactate			

Note: ⇓ = decrease, ⇑ = increase, ⇔ = no effect, ⇓⇑ = altered.

Fill in the following table with the major markers of overtraining presented in the literature:

	Suggested markers
Physiologic and performance	
Psychologic/information processing	
Immunologic	
Biochemical	

Exercise 3: Psychologic Markers of Overtraining

What two factors associated with the overtraining phenomenon have been suggested to occur?

1.

2.

Which two mood states are the most sensitive to psychologic overtraining?

1.

2.

Which two moods states have been suggested to give insight into the onset of psychologic overtraining that can lead to performance decrements and mood disturbances?

1.

2.

What are the six potential mechanisms that have been suggested to contribute to the overtraining phenomenon?

1.

2.

3.

4.

5.

6.

Exercise 4: Central Fatigue Hypothesis

What two factors have classically been associated with fatigue displayed during prolonged exercise?

1.

2.

Fill in the following table:

Variable	Effect of prolonged exercise
Muscle glycogen utilization	
Fat oxidation	
Oxidation of leucine	
Oxidation of isoleucine	
Oxidation of valine	
Note: ⇓ = decrease, ⇑ = increase, ⇔ = no effect.	

Explain how decreased availability of BCAAs and an increase in free fatty acid metabolism results in increases in the release of tryptophan. Explain how this could impact central fatigue.

Exercise 5: Value of Assessment Considerations to Limit Overtraining

What are three health history/exercise history categories that should be addressed before planning a training program?

1.

2.

3.

What are four fitness parameters that should be assessed before constructing a training program?

1.

2.

3.

4.

Explain why a needs analysis should be completed before constructing a training program.

What are four things that should be collected from a dietary recall before initiating a training program?

1.
2.
3.
4.

How does a needs analysis and a nutritional analysis help prevent overtraining?

Exercise 6: Concept of Periodization to Reduce Overtraining

What is the general adaptation syndrome?

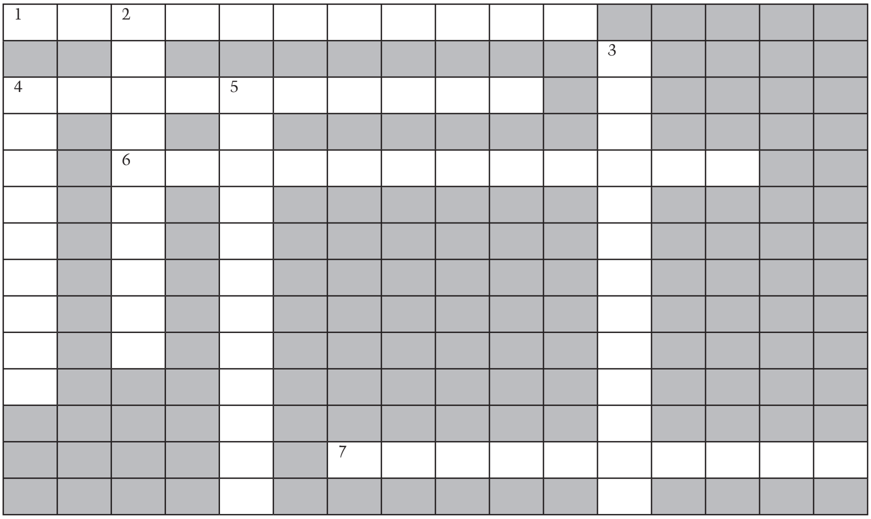
List and describe the three phases associated with general adaptation syndrome:

1.
2.
3.

What are the five phases associated with a periodized training model?

1.
2.
3.
4.
5.

Explain why adequate recovery is necessary to avoid overtraining.



Across:

1. The type of overtraining associated with strength/power athletes
4. An overall training plan, such as planning an athlete's training for a competition 1 year away
6. Accumulation of training and nontraining stress that results in short-term performance decrements
7. Is released from albumin in increasing concentrations as one exercises

Down:

2. One-week training cycles
3. A systematic progressive training plan that maximizes performance while minimizing the chances for overtraining
4. Training cycles that last from weeks to months
5. Accumulation of training and nontraining stress that results in long-term performance decrements

Exercise 7: Key Nutritional Considerations That Enhance Immune Function and Delay Central Fatigue

Moderate levels of training and exercise result in _________ immune system functionality, whereas intense, prolonged exercise can result in a __________ of the immune system for up to _______ 6 hours after the training bout.

Athletes who are overtrained are more susceptible to ______________.

What is glutamine?

What are two important roles of glutamine?

1.

2.

What role does glutamine have in the immune system, and what happens to glutamine when an athlete undertakes prolonged, intense training?

What is the effect of supplementing the diet with protein on the immune function of clinical patients with protein deficiencies?

What is vitamin C?

How does vitamin C supplementation relate to immune function during periods of prolonged, intense exercise?

What is zinc and how does it impact the immune system?

Exercise 8: Eat to Compete: Dietary Necessities to Control Overtraining and Promote Recovery

Why are the RDA guidelines for caloric intake not applicable for athletes participating in rigorous training? Give an example.

What is meant by the term dietary balance?

What are four recommendations for the timing of food consumption for athletes in relation to a competition or practice session?

1.

2.

3.

4.

What is the basic dietary breakdown that has been recommended?

1. Carbohydrates: ______________
2. Protein: ______________
3. Fats: ______________

How many meals a day have been recommended? ______________

What is the most important ergogenic nutritional aid for athletes? Why?

How much water should athletes drink before a training session?

What are two common mistakes made in regard to hydration by athletes?

1.
2.

What is an athlete's normal sweat rate, and how much water needs to be consumed to reduce the risk of dehydration?

What are five things that occur when drinking glucose/electrolyte solutions during intensive/extensive exercise training?

1.
2.
3.
4.
5.

What is the general recommendation for the consumption of glucose/electrolyte drinks?

Why is carbohydrate consumption important?

What is the concept of carbohydrate loading?

What is the glycemic index?

What is the protein recommendation for improving recovery?

What are five examples of high-quality proteins?

1.
2.
3.
4.
5.

What are five examples of high-quality protein supplements?

1.
2.
3.
4.
5.

What are the basic recommendations for fat consumption?

List and explain the benefits of the three amino acid options presented.

1.
2.
3.

Review Test

1. Which of the following apply to overreaching?
   a. Short-term increases in performance
   b. Short-term decreases in performance
   c. Long-term decreases in performance
   d. a and c
   e. b and c

2. Sympathetic overtraining is associated with:
   a. Endurance exercise
   b. Aerobic exercise
   c. Strength and power exercise
   d. Anaerobic exercise
   e. a and b
   f. c and d

3. Overtraining can be caused by all of the following except:
   a. Large increases in training volume
   b. Increases in training intensity
   c. Increases in frequency of training
   d. Long periods of time away from training.

4. The most sensitive psychologic factor associated with overtraining is:
   a. Fatigue
   b. Vigor
   c. Depression
   d. Anger
   e. a and b
   f. c and d

5. A potential mechanism for overtraining is:
   a. Chronic changes to the neuroendocrine environment
   b. Decreased serotonin levels
   c. Combined effect of exercise and life stress causing the athlete to reach the super-compensation phase
   d. None of the above

6. With a decrease in muscle glycogen stores, fat oxidation:
   a. Increases
   b. Decreases
   c. Is unaffected

7. Increases in free fatty acids in the blood are accompanied by increases in:
   a. A decreased release of albumin
   b. The release of tryptophan from albumin
   c. An increase in the ratio of free tryptophan to branched-chain amino acid ratio
   d. a and c
   e. b and c

8. A decrease in muscle glycogen stores is associated with increases in the oxidation of:
   a. Albumin
   b. Leucine
   c. Tryptophan
   d. None of the above

9. An increase in the tryptophan to branched-chain amino acid ratio is associated with all of the following except:
   a. An increased occurrence of central fatigue
   b. Increased formation of serotonin
   c. An increased occurrence of peripheral fatigue
   d. None of the above

10. A needs analysis would include all of the following except a(n):
    a. Training history
    b. Dietary evaluation
    c. Performance assessment
    d. Intelligence test

11. Which of the following represents the first stage of the general adaptation syndrome?
    a. Super-compensation
    b. Alarm
    c. Exhaustion
    d. None of the above

12. A year-long training cycle would be termed a(n):
    a. Microcycle
    b. Mesocycle
    c. Macrocycle
    d. Quadrilinear cycle

13. After the completion of the preparatory phase of training, athletes typically move into the:
    a. Transition I phase
    b. Hypertrophy phase
    c. Strength phase
    d. Maintenance phase

14. The transition I phase of training is considered a detraining phase.
    a. True
    b. False

15. Which is the most abundant amino acid in the body?
    a. Creatine
    b. Glutamine
    c. Leucine
    d. Isoleucine

16. The immune system can be suppressed for up to _______ after exercise.
    a. 1 hour
    b. 3 hours
    c. 4 hours
    d. 6 hours

17. Individuals who are involved in low-intensity exercise 3 times per week typically require _______ kilocalories per day.
    a. 1800–2400
    b. 2600–4000
    c. 800–1200
    d. >5000

18. Athletes should ingest ______ grams of carbohydrate and ________ grams protein 60 minutes before exercise.
    a. 5–10, 30–50
    b. 30–50, 5–10
    c. 10–30, 20–50
    d. 50, 0

19. To increase protein synthesis and improve recovery, athletes should consume _______ grams per kilogram body mass per day.
    a. 0.8–1.0
    b. 1.0–1.5
    c. 1.5–2.0
    d. >2.5

20. Signs of aerobic overtraining can include all of the following except:
    a. Increases in total testosterone
    b. Decreases in muscle glycogen levels
    c. Decreases in percent body fat
    d. a and b
    e. b and c

Review of Terminology

Overtraining and Overreaching	**Sympathetic and Parasympathetic Overtraining**	**Psychologic Markers of Overtraining**
Overreaching	Aerobic	General Adaptive System
Overtraining	Anaerobic	
Overtraining Syndrome	Parasympathetic Overtraining	**Central Fatigue Hypothesis**
Restoration	Sympathetic Overtraining	Albumin
		Branched-Chain Amino Acids
Value of Assessment	**Concept of Periodization**	Central Fatigue
Exercise History	Hypertrophy	Glycogen
Health History	Macrocycle	Hypoglycemia
Macronutrient	Maintenance	Hypoglycemia
Needs Analysis	Mesocycle	Tryptophan
	Microcycle	
Key Nutritional Considerations	Periodization	**Eat to Compete**
Amino Acid	Power	Amino Acids
Echinacea	Strength	Calorie
Glutamine		Creatine
Hypoglutamina		Dehydration
Lymphocyte		Electrolyte
Protein		Glutamine
Vitamin C		Hydration
Zinc		

Important Abbreviations

BCAA	GAS
CNS	GES
FFA	URTIs

Part II
Exercise Principles and Assessment

7
Principles of Exercise Training

Objectives

On the completion of this chapter, you will be able to:

1. Distinguish between health and fitness benefits of both aerobic and resistance training.
2. Define training volume and intensity for both aerobic and resistance training.
3. Understand the training principles of overload, specificity, and individualization.
4. Explain the possible benefits of both warmup and flexibility training on performance and injury prevention.
5. Design both an aerobic and resistance training session that meets the recommended guidelines for training frequency, duration, and intensity.
6. Learn to implement increases in aerobic and resistance training programs as fitness improves.

Learning Exercises

Exercise 1: Fundamental Training Principles

What are two fundamental training variables that are common to both aerobic and resistance training?

1.

2.

The total distance accomplished or the total time of training in an endurance activity represents the ________, while ________ is often represented as a percentage of maximum heart rate.

The total number of repetitions or the ______________ in a resistance training program are used to represent ____________, while __________ is represented by the percentage of a one repetition maximum for the particular lift.

How does one calculate the total weight lifted in a resistance training program?

____________ × ____________ = _______________

If Bob is 45 years old, what would be his age predicted maximum heart rate and his training heart rate if he wanted to train at 75% of maximum?

Maximum Heart Rate = _________________________

75% Maximum = _________________________

Define the following terms:

1. Overload:
2. Specificity:
3. Individuality:

What are three possible ways that overload can be accomplished in a resistance training program?

1.

2.

3.

Explain the concept of muscle group specificity.

Explain the concept of individualization.

What are 6 things that may attribute to the effectiveness of a warm-up?

1.
2.
3.
4.
5.
6.

What is an active warm-up?

Explain how an in what conditions an active warm-up is effective.

Explain the components of a warm-up period.

Explain the type of stretching that should be included in a warm-up.

Exercise 2: Training Frequency

What is meant by the term training frequency?

Fill in the following table:

Level of Training	**Aerobic Training**	
Untrained		
Moderately Trained		
Highly Trained		
Level of Training	**Resistance Training**	
	Total Body Lifting	**Muscle Group Training**
Novice Lifters		
Intermediate Lifters		
Advanced Lifters		

Exercise 3: Training Duration

What are the 5 factors that contribute to the duration of a resistance training program?

1.

2.

3.

4.

5.

When examining health and wellness based resistance training:

1. How many exercises per major muscle group should be performed?
2. How many exercises should be performed in a workout?

Explain the difference between single-joint and multi-joint exercise. In your explanation give specific examples.

What are the benefits of ________________?

1. Single Joint Exercises:
2. Multi-Joint Exercises:

Compare and contrast the benefits of 1–3 sets of 8–12 repetitions of resistance training to 3–4 sets of 8–12 repetitions.

What three things occur during an inter-set or inter-exercise rest period?

1.

2.

3.

Fill in the following table with the recommended rest intervals for resistance training.

	Recommended Rest Interval
Training for Muscular Strength with Multi-Joint Exercises	
Training with Single Joint Exercises	
Training for Muscle Hypertrophy	

Explain the differences in recommended lifting velocities for beginning, intermediate and advanced athletes.

Fill in the following table with the basic aerobic guidelines:

Frequency	Volume	Intensity	Type of Activity

Exercise 4: Training Intensity

Explain the concept of training intensity in relation to maximum heart rate with regard to health wellness, beginning training, and the lowest heart rates that have produced cardiovascular benefits.

Fill in the following table with the optimal resistance training intensities:

Training for Maximal Strength	**Optimal Training Intensity**
	60% of 1 RM
Moderately Trained Athlete	
Advanced Athlete	

Resistances of __________ RM may be most effective for increasing 1 RM strength.

Fill in the following table with the basic resistance training guideline:

	Frequency	**Volume**	**Intensity**	**Type of Activity**
Total Body Training				
Body Part Training				

Exercise 5: Training Progression

What is meant by the term training progression?

Using ____________ for aerobic training and ________ resistances for resistance training endure training progression.

As fitness increases, what happens to the work load an athlete can handle at a specific heart rate range?

As strength increases, what happens to the amount of resistance an athlete can lift at a specific repetition range?

What are three possible ways to incorporate training variation into an aerobic training program?

1.

2.

3.

What are three possible ways to induce training variation into a resistance training regime?

1.

2.

3.

What are two major type of resistance training periodization that have been investigated and shown to induce greater improvements in muscular strength, muscular power, and body composition?

1.

2.

Explain the differences between the two types of periodization presented.

Review Test

1. The total weight lifted represents ____________.
   a. the volume of the resistance training program
   b. the intensity of the resistance training program
   c. a and b
   d. none of the above

2. Aerobic training volume is considered to be ____________.
   a. total distance accomplished
   b. total time of the training program
   c. the percentage of maximum heart rate
   d. a and b
   e. b and c

3. If Jane were to squat 60 kilograms or 70% of her 1-RM for her target resistance training intensity what is her 1-RM?
   a. 100 kg
   b. 85 kg
   c. 75 kg
   d. 60 kg

4. Which of the following would be characteristics of an RM weight?
   a. as many repetition as possible were performed
   b. if you were performing a 10RM you could do 11 repetitions
   c. strength gains only occur when performing RM training
   d. a and b
   e. b and c

5. If Lori is 25 years old what would be 70% of her maximum heart rate?
   a. 195 beats per minute
   b. 154 beats per minute
   c. 137 beats per minute
   d. 120 beats per minute

6. All of the following can be used to induce an overload stimulus in resistance training *except*:
   a. Using RM resistances
   b. Increasing the rest interval length
   c. Increasing the number of sets
   d. Increasing the number of exercises

7. If Mark were to bicycle 5 days a week for 60 minutes each session for 12 months you would expect to see a primary increase in oxidative enzymes in the musculature of the upper body.
   a. True
   b. False

8. All of the following contribute to the effectiveness of a warm-up session *except*.
   a. decrease in initial oxygen consumption
   b. increase nerve conduction rate
   c. altered muscular force-velocity relationship
   d. increased muscle tissue temperature

9. Typical Health Benefits associated with endurance training include?
   a. increased muscular hypertrophy
   b. increased resting heart rate
   c. decreased percent body fat
   d. a and b
   e. a and c

10. Typical health benefits associated with resistance training include?
    a. increased metabolic rate
    b. increased muscular hypertrophy
    c. increased risk of osteoporosis
    d. a and b
    e. b and c

11. All of the following are examples of fitness benefits associated with resistance training *except*.
    a. increased lean body mass
    b. increased maximal oxygen consumption
    c. increased strength
    d. increased muscular power

12. The optimal aerobic training frequency for an untrained individual is 6–7 days per week.
    a. True
    b. False

13. Individualization of a training program regardless of whether or not it involves aerobic or anaerobic should only be undertaken when working with elite athletes.
    a. True
    b. False

14. All of the following are recommendations for resistance training programs of advanced weight trained athletes *except*:
    a. the optimal mean training intensity should fall around 85% of 1 RM
    b. when performing a total body workout training should be between 2–3 days per week
    c. the optimal rest interval when targeting strength gains should be 30s-1 minute
    d. the athlete should perform between 4–5 sets per body part to maximize gains

15. All of the following are methods of introducing variation into an aerobic training program *except*:
    a. Training at different percentages of maximum heart rate
    b. Running different routes on different days.
    c. Changing the duration of each training bout
    d. Using the same mode of aerobic training every day.

16. In order to induce training variation into a resistance training regime you can:
    a. Change the rest period between sets
    b. Maintain the same repetition and set scheme each day
    c. Alter the exercises used in the training program
    d. Vary the number of exercises performed in the training session.

17. Periodization produces superior results to non-varied training.
    a. True
    b. False

18. The optimal frequency of training for a beginning weight trainer is _____.
    a. 6 times per week
    b. 4 times per week
    c. 3 times per week
    d. 2 times per week

19. All of the following are attributable to the classic model of periodization *except*:
    a. Initial training is characterized by high volume and low intensity of training
    b. Each phase of training lasts a minimum of 8 weeks
    c. Is sometimes referred to as linear periodization
    d. The highest intensities and volumes of training are encountered around a time point where maximal performances is needed

20. If you were to perform a 3–5 RM training load on Monday, a 12–15 RM load on Wednesday, and an 8–10 RM load on Friday you would be attempting a non-linear periodization based program.
 a. True
 b. False

Review of Terminology

Fundamental Training Principles	**Training Frequency**	**Training Intensity**
Active Warm-up	Frequency	Heart Rate Maximum
Aerobic Training		Intensity
Failure	**Training Duration**	Repetition Maximum
Individualization	Duration	
Intensity	Multi-Joint Exercise	**Training Progression**
Maximum Heart Rate	Muscular Strength	Linear Periodization
Muscle Group Specificity	Rest Period	Periodization
Overload	Single Joint Exercise	Rest Intervals
Proprioceptive Neuromuscular Facilitation		Training Intensity
Resistance Training		Training Variation
Specificity		Undulating Periodization
Static Stretching		
Volume		

8
Laboratory and Field Techniques for Measuring Performance

Objectives

On the completion of this chapter, you will be able to:

1. Understand the rationale for implementing testing procedures before, during, and after a training program has been designed.
2. Explain the strengths and weaknesses of laboratory- and field-based testing programs.
3. Conceptualize the importance of measuring aerobic capacity, anaerobic capacity, muscular force, power, and flexibility in a testing program.
4. Describe and differentiate the different methods used to evaluate aerobic power.
5. Explain the contributing factors associated with an individual's VO_2 max.
6. Understand the key criteria for determining if a VO_2 max has been achieved.
7. Give a rationale for the value of testing the lactate threshold.
8. Explain the different methods for assessing anaerobic power, muscular strength, and flexibility.
9. Diagnose strengths and weaknesses an athlete might have based on the results achieved in a battery of physiologic tests.
10. Calculate power from a vertical jump and maximal strength from a repetition maximum weight

Learning Exercises

Exercise 1: Testing Basics

Appropriate testing provides a general overview of an athlete's ______ ______ and ______ status as well as a baseline measurement of the athlete's ability.

Periodic testing allows for the coach to monitor the athlete's _______ ___ and _________ and evaluate the overall effectiveness of the training program.

What are five objective physiologic measures that can be evaluated with an appropriate testing program?

1.

2.

3.

4.

5.

One key thing to consider with a testing program is that testing should _______ be used as a training tool.

What are two things that a testing program cannot do?

1.

2.

Compare and contrast the benefits and limitations of laboratory and field tests.

Laboratory tests tend to be more ____________, whereas field tests tend to be more ___________.

What factors make field tests less reliable than laboratory tests?

What are four things to consider when attempting to create an effective testing program?

1.
2.
3.
4.

What are the seven factors that are typically measured in a testing program?

1.
2.
3.
4.
5.
6.
7.

Exercise 2: Assessment of Maximal Aerobic Power

VO_2 max is also known as ___________ or ________________.

Explain what is represented by the term VO_2 max.

Differentiate between relative and absolute VO_2 max. What does each measure tell you?

Give an example of how two individuals of different size can be compared using a relative VO_2 max.

What are some examples of sports in which the determination of VO_2 max would be important?

1.
2.
3.

The greater the VO_2 max, the greater the ________________.

What are the three physiologic systems that are the primary determinants of a person's VO_2 max?

1.

2.

3.

Generally, it is believed that the ____________ is able to oxygenate the blood at all levels of exercise intensity. However, in _________ individuals, this system might limit their VO_2 max.

Explain how the three physiologic systems evaluated in a VO_2 max could potentially limit performance.

What are the three potential methods for evaluating a person's VO_2 max?

1.

2.

3.

Explain the benefits of using a prediction equation or a field-based test to estimate VO_2 max

What are three examples of a field test?

1.

2.

3.

Compare and contrast the accuracy and reliability of a prediction equation-based assessment of VO_2 max with that of a field test.

The estimation of VO_2 max can also be achieved by utilizing heart rate responses, because heart rate is related to exercise intensity and oxygen uptake in a ________ manner.

What are the four assumptions that must be meet when performing a ________ exercise test?

1.
2.
3.
4.

The YMCA Cycle Test is probably the most frequently used ________ exercise test.

The YMCA Cycle Test requires the subject to:

1.
2.

During the YMCA Cycle Test, heart rate is recorded during the last __________ seconds of the second and third stage of exercise.

<u>Read the following passage and describe how the YMCA bike test would proceed.</u>

Jane is cycling at 150 kg·m·min^{-1} and completes the first stage of the YMCA protocol. At the end of the stage, you record a heart rate of 90 beats per minute.

1. What would Jane's second workload be?
2. What would Jane's third workload be?
3. What would Jane's fourth workload be?

Because Jane is 45 years old, what would be the two steady-state heart rate values you would want to achieve?

1. ________________
2. ________________

What are three benefits of using the YMCA Cycle Test?

1.
2.
3.

What is the major limiter in the use of the YMCA Cycle Test?

What is the most accurate method for assessing VO_2 max?

What are the equation and the name of the equation that VO_2 max is based on?

1. Name:
2. Equation: ____________ = _________ × ____________

What do the following abbreviations represent?

1. VO_2 = __________________
2. Q = __________________
3. a-vO_2 difference = __________________

Because the assessment of Q and the a-vO_2 difference is considered to be very invasive, techniques have been developed to measure oxygen consumption by other methods. What are the three things that can be measured?

1.
2.
3.

In a general sense, the measurement of _________ is similar to the measurement of Q and the measurement of _____________ is synonymous with the measurement of ______________.

Discuss the equipment that is needed to measure ventilation and the content of oxygen in expired air.

What percentage of oxygen is in inspired air? __________________

What three things are typically included in commercially packaged metabolic assessment systems?

1.
2.
3.

To perform a test of aerobic power, it is also important to have an ergometer, which allows for precise control of __________.

What are the two most common ergometers used when testing aerobic power?

1.

2.

What two methods are often used to monitor heart rate during a test of aerobic power?

1.

2.

What is the Borg Ratings of Perceived Exertion (RPE) scale?

Explain what a graded exercise test is and what it is used to test.

List the four factors included in the decision-making process when choosing a graded exercise test and describe each factor?

1.

2.

3.

4.

What are the two most common treadmill tests used for the purpose of determining aerobic power?

1.

2.

Give an example of a cycle ergometer test for aerobic power. In this example, differentiate between protocols for men and women.

What are the three things that one can garner from a VO_2 max test?

1.

2.

3.

What are the four objective criteria used to confirm if a maximal effort has been achieved during a graded exercise test?

1.

2.

3.

4.

The lactate threshold is the workload or ___________ at which blood ________ begins to accumulate in response to a graded exercise test.

Explain why lactic acid does not accumulate during low-intensity exercise.

Explain why lactic acid accumulates as intensity of exercise increases.

The lactate threshold is also referred to as the ___________.

What is the ventilatory threshold, and how is it defined?

Why is the lactate threshold important to test when evaluating endurance athletes?

There is a high degree of correlation between the lactate threshold and ___________.

Explain in detail how the lactate threshold is evaluated.

Exercise 3: Assessment of Anaerobic Power

Anaerobic means without _________________, thus anaerobic work occurs without _________.

List and give a basic description of the three primary energy systems:

1. _________________:

2. _________________:

3. _________________:

The _______________ energy system can replenish ATP for only a few seconds.

The _______________ energy system can maximally support ATP needs for up to 2 minutes.

The _______________ energy system cannot support ATP needs during maximal exercise, it can only support energy needs during submaximal exercise.

When testing anaerobic performance, two major delineations can be made.

1.

2.

What are the three stores of energy that can affect the outcome of an anaerobic test?

1.

2.

3.

Match the following sport activity with the appropriate energy system:

______________	Discus throw	A) Glycolysis
______________	400-m sprint	B) Immediate
______________	40-m sprint	C) Oxidative
______________	Average length of a football play	
______________	100-m swim	
______________	200-m sprint	
______________	1 RM squat	
______________	Golf swing	
______________	5-km run	

What is the Margaria Staircase Test and what does it test?

Explain in detail the traditional Margaria Staircase Test protocol.

If Randy weighs 70 kg, the distance between each mat is 1.14 m, and he completes the test in 20 seconds, what is his anaerobic power?

What is the Wingate Test, where is the test performed, and how long does it last?

What is the basic protocol for conducting a Wingate Test?

During a Wingate Test _______________.

1. What energy system is assumed to be tested during the first 5 seconds?
2. What power value is usually achieved in the first 5 seconds?
3. What energy system is assumed to be tested over the duration of the test?
4. What power value is achieved across the total test?

Describe the basic concept behind the utilization of a vertical jump test for the assessment of anaerobic power.

If Guy is 50 years old, weighs 65 kg, and jumps 76 cm, what is his leg power?

Exercise 4: Assessment of Muscular Strength

What are three reasons to perform periodic assessments of muscular strength?

1.
2.
3.

Explain in detail what a 1 RM test is.

What are the two most common movements tested in the assessment of muscular strength?

1.

2.

Explain in detail the procedures for administering a 1 RM test.

If Janna can bench 60 kg for an 8 RM and she is untrained, what would be her predicted 1 RM?

If Mark can bench 70 kg for a 9 RM and is trained, what would be his predicted 1 RM?

Define what is meant by an isometric strength test.

The peak force value achieved during an isometric test is only applicable at the ____________, which was evaluated during the test.

Isometric testing should be performed through a variety of _______________.

What does an isokinetic test involve?

What measures do you get with an isokinetic test?

What is an isotonic test? Give an example of an isotonic movement.

Exercise 5: Assessment of Flexibility

Define what is meant by flexibility.

Flexibility could contribute to ______________ and ___________ when performing athletic events.

What are five factors that might contribute to one's flexibility?

1.

2.

3.

4.

5.

What are three sit and reach tests that are frequently used?

1.

2.

3.

In detail, explain the basic protocols for the three major sit and reach tests.

1.

2.

3.

If Steve is a 52-year-old man who has a sit and reach of 11, what percentile would he fall into?

Review Test

1. If Steve is a 57-year-old man who has a sit and reach of 9 inches, what would be his percentile rank according to the YMCA Sit and Reach norms?
   a. 20
   b. 40
   c. 60
   d. 80

2. All of the following have been suggested to contribute to an individual's flexibility except:
   a. The tightness of ligaments
   b. The tightness of the muscles
   c. The individual's age
   d. The training status of the individual
   e. All of the above
   f. None of the above

3. Muscular strength testing in which the velocity of the movement is constant would be an example of a(n):
   a. Isotonic test
   b. Isometric test
   c. Isokinetic test
   d. Isoinertial test

4. During an isometric test, the peak force registered is an excellent representation of the individual's overall muscular strength for the muscle group tested.
   a. True
   b. False

5. When performing the YMCA Sit and Reach Test, all of the following are considerations except:
   a. Only one trial needs to be performed
   b. Subjects should not be wearing shoes when tested
   c. The legs should be extended
   d. The heals of the feet should be ~10–12 inches apart
   e. The tester should not press down on the subject's knees during the test

6. Danny is a 45-year-old untrained man who performed a 9 RM with 100 kg during a bench press test. What would be his predicted 1 RM?
   a. 150
   b. 147
   c. 125
   d. 130

7. Which of the following can be gathered from a 1 RM back squat test?
   a. Monitoring of training program effectiveness
   b. Assessment of lower body power
   c. Assessment of lower body strength
   d. a and b
   e. a and c
   f. None of the above

8. When performing a 1 RM test for maximal strength, it is important to include a 1- to 3-minute recovery period between each attempt.
   a. True
   b. False

9. A 7–10 RM is approximately ___________% of an individual's 1 RM.
   a. 88
   b. 78
   c. 68
   d. 58

10. John is 26 years old, weighs 77 kg, and can jump 67 cm. What do you know about him?
    a. He would be classified as having very good leg power
    b. He would have a leg power of ~187 $kg{\cdot}m{\cdot}s^{-1}$
    c. a and b
    d. None of the above

11. What does the traditional Wingate Test assess?
    a. The entire test gives an estimate of oxidative capacity
    b. The duration of the test estimates glycolytic capacity
    c. The peak power value gives an estimate of the immediate energy system's capacity.
    d. a and b
    e. b and c

12. The resistance used in a traditional Wingate Test is ________ grams per kilogram body mass.
    a. 100
    b. 85
    c. 75
    d. 65

13. Erin is a track athlete who has a peak power output of 600 watts and an average power output of 380 at a body mass of 69 kg. All of the following are true about Erin **EXCEPT**:
    a. She generates 8.7 watts per kilogram body mass
    b. She is ranked in the 90th percentile for peak power
    c. She is ranked around the 50th percentile for average power

14. An example of a sporting activity that primarily uses the immediate energy system is:
    a. The performance of a discus throw
    b. The performance of a 200-m swim
    c. The performance of a 400-m run
    d. The performance of an ice hockey shift

15. The glycolytic energy system maximally supplies energy for up to 2 minutes of exercise before reliance on this system declines.
    a. True
    b. False

16. All of the following relate to the accumulation of lactic acid in the blood **EXCEPT**:
    a. The ventilatory threshold
    b. The lactate threshold
    c. The oxidative cut point
    d. The anaerobic threshold

17. Which of the following is often used as confirmation of a maximal effort during a VO_2 max test?
    a. An RPE greater than 12
    b. A heart rate within 10 beats per minute of an age-predicted maximum
    c. A respiratory exchange ratio less than 1.0
    d. A rapid decline in oxygen consumption

18. The Bruce protocol is one of the more popular cycle ergometer protocols for determining aerobic power.
    a. True
    b. False

19. A graded exercise test should last around 8–12 minutes.
    a. True
    b. False

20. Which of the following procedures can be used to estimate aerobic power?
    a. The Wingate Test
    b. YMCA Cycle Ergometer Test
    c. Bruce Treadmill Protocol
    d. a and b
    e. b and c

Review of Terminology

<u>**Testing Basics**</u>	<u>**Assessment of Aerobic Power**</u>	<u>**Assessment of Anaerobic Power**</u>
Field Test	Absolute VO_2 max	Anaerobic
Laboratory Test	Anaerobic Threshold	Anaerobic Capacity
Reliability	Arteriovenous Difference	Anaerobic Power
Validity	Cardiac Output	Anaerobic Work
	Cardiorespiratory Endurance	Average Power
<u>**Assessment of Muscular Strength**</u>	Cardiovascular System	Glycolytic Energy System
Isokinetic	Cycle Ergometer	Immediate Energy System
Isometric	Ergometer	Margaria Staircase Test
Isotonic	Graded Exercise Test	Oxidative Energy System
	Heart Rate	Peak Power
<u>**Assessment of Flexibility**</u>	Lactate Threshold	Vertical Jump
Flexibility	Maximal Aerobic Power	Wingate Test
Sit and Reach	Maximal Oxygen Uptake	
	Musculoskeletal System	
	Oxygen	
	Oxygen Consumption	
	Prediction Equation	
	Relative VO_2 max	
	Respiratory System	
	Treadmill	
	Ventilation	
	Ventilatory Threshold	
	VO_2 max	
	Watt	

Important Abbreviations

a-vO_2 difference	10 RM
PA	RPE
%BF	VO_2
Q	VO_2 max
1 RM	

9
Methods of Body Composition Assessment

Objectives

On the completion of this chapter, you will be able to:

1. Understand the various levels of body composition assessment.
2. Describe the basic procedures associated with hydrostatic weighing.
3. Demonstrate how to calculate body composition from body density.
4. Discuss the limitations associated with the various methods for assessing body composition.
5. Explain the basic procedures associated with skinfold analysis.
6. Understand the methods associated with air-displacement plethysmography.
7. Describe the factors that can affect the accuracy of the different methods of assessing body composition.
8. Discuss the basic principles behind the use of bioelectrical impedance analysis of body composition.
9. Explain the basic procedures and limitations associated with dual-energy X-ray absorptiometry.
10. Demonstrate the basic calculations associated with the body mass index.
11. Understand the limitations associated with the body mass index.
12. Describe the differences among two-, three-, and four-compartment models for assessing body composition.
13. Illustrate the different combinations of procedures that can be used to make two-, three-, and four-compartment body composition assessment models.

Learning Exercises

Exercise 1: Body Composition Levels

The atomic level 95% of the body mass is accounted for by __________.

1.

2.

3.

4.

What are four additional elements that contribute to the 5% of the body mass?

1.

2.

3.

4.

What are two examples of methods for assessing the atomic level?

1.

2.

Sixty percent of the molecular level is accounted for by ____________ in men whereas approximately 5% is accounted for by ________________.

What are the five components of a molecular-level analysis?

1.

2.

3.

4.

5.

What are the three levels of a cellular-level analysis?

1.

2.

3.

What are the five levels of a tissue-system-level analysis?

1.
2.
3.
4.
5.

What are two techniques utilized for a tissue-system-level analysis?

1.
2.

A whole-body analysis includes what four factors?

1.
2.
3.
4.

Exercise 2: Underwater Weighing

Underwater weighing is also known as ____________ or ___________.

List the two compartments evaluated in a two-compartment model and explain what components of the body contribute to these compartments.

1.
2.

What are the four most common two-compartment models for evaluating body composition?

1.
2.
3.
4.

Density is defined as __________ divided by _____________.

Why is it important to know density when looking at a two-compartment model of body composition analysis?

What is the density of:

1. Water = _________________
2. Fat-free mass = _________________

The closer the body density is to _______________, the greater the body fat of the person, whereas the closer the density is to ___________, the leaner the person.

Explain the principle that serves as the basis for hydrodensitometry.

What is the basic formula for volume?

___________ = _______________/______________

What is the formula for body density?

Body density = _______________/______________

What is the formula for body volume?

Body volume =

The volume of air in the lungs after a maximal exhalation is the ____ _________. This can be estimated by what three methods?

1.

2.

3.

In complete detail, explain the basic procedures used to perform a body fat analysis using hydrostatic weighing?

What are the formulas for the following two main equations used to convert body density into body composition?

1. Brozek equation:
2. Siri equation:

Fill in the following table based on the assumptions made by the Siri and Brozek equations:

	kg/L	%
Water		
Protein		
Bone mineral		
Nonbone mineral		

Resistance training tends to stimulate hypertrophy resulting in a change in aggregate density of FFM, thus resulting in a(n) __________ of percent body fat.

The density of fat has been demonstrated to be _________ in black compared with whites.

What is the total cumulative error for body fat presented by Ellis?

Exercise 3: Skinfold Thickness

How do skinfold measurement techniques differ from hydrostatic weighing?

When measuring skinfold thickness, the _________ of fat is being measured.

In detail, describe the basic procedure for measuring skinfolds.

Skinfold measurements are used to predict _______, which can then be used to estimate body fat percentage with either the ______ or ____ ____ formula.

What are two major limitations that are innate to skinfold procedures?

1.

2.

Explain the difference between a three- and seven-site skinfold test.

Why might you want to include age in a skinfold equation?

What are two things that impact the accuracy of prediction equations?

1.

2.

What two standard statistical procedures are used to assess the accuracy of a prediction equation? Explain what they mean and how they are used.

1.

2.

Exercise 4: Air-Displacement Plethysmography

What are two disadvantages of using hydrostatic weighing?

1.

2.

Compare and contrast traditional hydrostatic weighing procedures with those of air-displacement plethysmography.

The air-displacement plethysmography analysis is based on a _________ compartment mode.

Once body density is determined by air-displacement plethysmography, the body density is plugged into the ___________ or ___________ formulas to predict body fat percentage.

The body fat percent for men is generally __________, whereas body fat percent for women is ____________.

What are four factors that can affect the accuracy of air-density plethysmography?

1.

2.

3.

4.

Exercise 5: Bioelectrical Impedance

Bioelectrical impedance is used to determine ________________.

Fat-free mass generally contains _________ of water per kilogram.

Generally, fat-free mass contains a high percentage of water and electrolytes and offers ________ resistance to the flow of electrical current than fat tissue.

The lower the resistance to the electrical current, the ________ the fat-free mass.

Because fat-free mass has an approximate water content of ______%, one could estimate fat-free mass by the following formula:

Fat free mass = _____________/________________

Discuss the accuracy and validity of bioelectrical impedance systems.

What six factors can affect the accuracy of a bioelectrical impedance system?

1.

2.

3.

4.

5.

6.

Exercise 6: Dual X-Ray Absorptiometry (DEXA)

What was the original diagnostic purpose of dual X-ray absorptiometry?

What are the three compartments that are assessed by DEXA?

1.

2.

3.

What are five factors that can affect the body composition measures when using the DEXA system?

1.
2.
3.
4.
5.

Discuss the accuracy of the classic pencil-beam and the more modern fan-beam DEXA systems.

What are the benefits of having body composition assessed via a DEXA system?

Exercise 7: Body Mass Index

What is the formula for the body mass index?

Body mass index = _____________/______________

Match the following body mass index values with their appropriate definition:

1. ___________	≥30	A) Underweight
2. ___________	= 18.5–24.9	B) Overweight
3. ___________	≤18.5	C) Normal
4. ___________	= 25–29.9	D) Obese

What is one of the major problems with the BMI?

If you were to use the BMI to evaluate athletes, what might you expect?

Exercise 8: Beyond the Two-Compartment Model

What are four factors that affect two-compartment models?

1.

2.

3.

4.

How might one create a three-compartment model for evaluating body composition?

How might one create a four-compartment model for the evaluation of body composition?

Review Test

1. At the molecular level, which of the following contributes the most to body mass?
   a. Minerals
   b. Water
   c. Lipids
   d. Proteins

2. At the tissue level, all of the following contribute to body mass except:
   a. Skeletal muscle
   b. Adipose
   c. Water
   d. Visceral organs

3. In the two-compartment model, the density of fat is assumed to be _____ kg/L.
   a. 1.1
   b. 1.0
   c. 0.9
   d. 0.8

4. Which body composition assessment technique is based on Archimedes Principle?
   a. Hydrostatic weighing
   b. Bioelectrical impedance analysis
   c. Skinfold assessment
   d. Dual X-ray absorptiometry

5. All of the following body composition assessment techniques are based on the two-compartment model except:
   a. Skinfold assessment
   b. Hydrostatic weighing
   c. Displacement plethysmography
   d. Dual X-ray absorptiometry

6. Which of the following body composition assessment techniques is the most popular field test method?
   a. Hydrostatic weighing
   b. Bioelectrical impedance analysis
   c. Skinfold assessment
   d. Dual X-ray absorptiometry

7. When using the Siri or Brozek equations, all of the following are assumptions made about the FFM components except:
   a. Bone mineral = 2.982 kg/L
   b. Water comprises 19.4%
   c. Minerals comprise 6.8%
   d. Nonbone mineral = 3.317 kg/L

8. One limitation of skinfold-based regression equations is that they are population specific.
   a. True
   b. False

9. Skinfold analysis is considered a very accurate method of assessing body fat because the only fat in the body is associated with subcutaneous stores.
   a. True
   b. False

10. Which of the following factors can affect the accuracy of an air-displacement plethysmography assessment of body composition?
    a. Air trapped in the hair
    b. Breathing pattern during the assessment
    c. a and b
    d. None of the above

11. Air-density plethysmography tends to overestimate the body fat percentage in men by ~3%.
    a. True
    b. False

12. Bioelectrical impedance is primarily a method for determining:
    a. Body water
    b. Body fat
    c. Body density
    d. All of the above

13. Which of the following would be most affected by the skill of the tester?
    a. Bioelectrical impedance
    b. Hydrostatic weighing
    c. Skinfold assessment
    d. Dual X-ray absorptiometry

14. A football player would likely be classified as being obese when using ____________ to assess body composition.
    a. Dual X-ray absorptiometry
    b. Bioelectrical impedance
    c. Hydrostatic weighing
    d. Body mass index

15. When using the bioelectrical impedance method of assessing body composition, water equals ~73% of fat free mass.
    a. True
    b. False

16. When using DEXA to assess body composition, which factors can affect the results?
    a. The anterior-posterior thickness of the person
    b. The gender of the person
    c. The software being used
    d. a and b
    e. a and c
    f. None of the above

17. When using DEXA, which tissue more readily absorbs X-ray energy?
    a. Muscle
    b. Cartilage
    c. Bone
    d. All of the above

18. The combination of hydrostatic weighing with a DEXA scan can be used to create a three-compartment model.
    a. True
    b. False

19. Bioelectrical impedance analyses are considered the gold standard of body composition assessment.
    a. True
    b. False

20. Which of the following is representative of a three-compartment model?
    a. Bone mass, bone-free mass, and fat mass
    b. Fat mass, total body water, and dry, fat-free solids
    c. Fat-free mass, fat mass, and lean body mass
    d. a and b
    e. b and c
    f. None of the above

Review of Terminology

Body Composition Levels	**Underwater Weighing**	**Skinfold Thickness**
Body Density	Archimedes Principle	Criterion Variable
Body Mass	Body Composition	Standard Error of the Estimate
Calcium	Brozek Equation	Variance
Carbon	Density	
Circumference	Hydrodensitometry	**Dual X-Ray Absorptiometry**
Extracellular Fluid	Hydrostatic Weighing	Fan-Beam DEXA
Extracellular Solids	Residual Volume	Pencil-Beam DEXA
Glycogen	Siri Equation	
Height	Underwater Weighing	
Hydrogen	Volume	
Lipids		
Nitrogen		
Oxygen		
Phosphorus		
Potassium		
Protein		
Sodium		

Important Abbreviations

ADP	FFM
BMI	FM
DEXA	R
DIA	SEE

10
Nutritional Assessment and Counseling of Athletes

Objectives

On the completion of this chapter, you will be able to:

1. Develop a basic understanding of the relationship between dietary practices and overall health and wellness.
2. Understand the basic components of the 2005 Dietary Guidelines for Americans.
3. Explain the components of an effective nutrition assessment program.
4. Describe the factors that impact an athlete's dietary practices.
5. Integrate the knowledge attained in previous chapters about body composition assessments with the nutritional assessment techniques in order to help athletes with their dietary practices.
6. Determine an athlete's optimal body weight and resting metabolic rate.
7. Explain the limitations of the body mass index as a tool for determining body composition.
8. Discuss the relationship between optimal body fat levels and an athlete's optimal body weight.
9. Develop a basic understanding of the methods for determining caloric needs.
10. Predict an athlete's basal metabolic rate and total caloric need depending on their activity levels.
11. Discuss the relationships among psychosocial factors, dietary practices, and lifestyle.
12. Determine the best method for assessing the dietary practices of athletes.
13. Establish an understanding of how to council athletes about their dietary practices.

Learning Exercises

Exercise 1: Basic Overview

What are seven factors that serve as the basis for an athlete's nutrition plan?

1.

2.

3.

4.

5.

6.

7.

What are five of the top 10 causes of death that are associated with either dietary excesses or imbalances?

1.

2.

3.

4.

5.

What percentage of all deaths in the United States each year can be associated with some sort of dietary issue?

What are three factors that are associated with inadequate diets?

1.

2.

3.

Exercise 2: Understanding the Dietary Literature Base

What are the nine key points that can be taken from the 2005 U.S. Dietary Guidelines?

1.
2.
3.
4.
5.
6.
7.
8.
9.

Discuss the importance of the formation of dietary guidelines and how politics can influence these guidelines. Include in your discussion an example (i.e., sugar).

Exercise 3: Basic Principles of Nutrition Assessment and Screening

What are the four principles that a classical nutrition assessment is based on?

1.
2.
3.
4.

Fill in the following table based on the proposed flowchart for the nutritional assessment of athletes:

Training program	
Physiologic demands	**Nutritional needs**
	Calories
Training routine	
Energy system used	
	Fluids
	Vitamins
Weight changes	

If during the assessment of an athlete, it is determined that disease-oriented situations such as diabetes, hypoglycemia, or eating disorders are noted, what should be done?

Exercise 4: Nutritional Assessment Strategies

Explain why it is important to assess an athlete's body weight? How does this relate to the dietary intervention?

List and describe the three methods that are applied and evaluated when determining an athlete's optimal body weight:

1. ________________________:
2. ________________________:
3. ________________________:

What anthropometric measures are useful in determining an athlete's optimal body weight?

1.
2.
3.

The determination of optimal body weight requires the use of __________, ___________, and ___________.

Explain what a field method of assessing body composition is.

What do the most common field methods for assessing body composition include?

1.

2.

3.

Explain why using BMI can be misleading when working with athletes.

What are some better methods for assessing body composition in athletes? What is a bioelectrical impedance analysis (BIA)?

What are the eight things that should be done to maximize the accuracy of a BIA?

1.

2.

3.

4.

5.

6.

7.

8.

Fill in the following table based on the health standards for percent body fat:

Gender	**Age**	**Recommendations for body fat levels**				
		Not recommended	**Low**	**Middle**	**Upper**	**Obesity**
Men						
	Young adult					
	Middle adult					
	Elderly					
Women						
	Young adult					
	Middle adult					
	Elderly					

Based on the following numbers, calculate the optimal body weight based on the desired percent body fat.

Present body weight:	165 pounds
Percent body fat:	18%
Desired body fat	12%
How many pounds of body fat:	______________
How many pounds of lean body mass:	______________
Total pounds at 12% body fat:	______________

Exercise 5: Guidelines for Acceptable Percent Body Fat Levels

Explain why athletes might want to manipulate their body fat or body mass.

What can happen to performance if an athlete undergoes rapid weight loss?

Explain why it is important to be attentive to the potential development of eating disorders.

Exercise 6: Determination of Calorie Requirements

What are two things that are needed to determine caloric needs?

1.
2.

Explain in detail the difference between direct and indirect calorimetry.

Explain the difference between the:

1. Respiratory exchange ratio:
2. Respiratory quotient:

What are five things that can be measured with portable devices and combined with age, gender, height, and weigh in order to estimate energy expenditure?

1.
2.
3.
4.
5.

Another estimate of energy needs can be determined by what three things?

1.
2.
3.

Define the resting metabolic rate.

Using the Harris-Benedict equation, what is the estimated resting metabolic rate?

Woman	**Man**
Age = 37 years Height = 5 ft. 5 in. Weight = 145 pounds	Age = 36 years Height = 5 ft. 10 in. Weight = 213 pounds
RMR =	RMR =

Explain how lean body mass relates to the prediction of resting metabolic rate. How does the predictive formula change?

With the resting metabolic rate determined above, fill in the following to determine the estimated total energy expenditure.

Woman	**Man**
RMR =	**RMR =**
This person is active **Total energy expenditure =**	This person is very active **Total energy expenditure =**

If the athlete wants to lose weight, what is the best way to create the calorie deficit?

Exercise 7: Eating and Lifestyle Patterns

What are the five W's that should be determined when evaluating an athletes diet?

1.
2.
3.
4.
5.

An athlete's lifestyle and patterns of stress can significantly affect what three factors?

1.
2.
3.

When evaluating an athlete's lifestyle, what are four examples of things that need to be evaluated?

1.
2.
3.
4.

Exercise 8: Dietary Assessment Tools

Match the dietary assessment tool to its appropriate definition:

Terms:

1. ________ Generic nutrition questionnaire
2. ________ 24-hour recall
3. ________ Food frequency form
4. ________ Food diary
5. ________ Food and activity record

Definitions:

a. Describes food intake, activity, and mood. Gives a very comprehensive picture of the athlete's lifestyle and how it affects mood.

b. A checklist that yields data about the kinds and frequency of foods that the athlete consumes.

c. A generic or universal questionnaire for evaluating nutritional intake.

d. A self-reported description of the food intake over a period of time. Usually between 3–7 days.

e. A dietary recall method that gives a picture of a period of time that is assumed to represent a broad picture of the athlete's typical food intake.

Exercise 9: Fitness and Laboratory Tests (Biochemical/Clinical)

Fill in the following physical fitness and laboratory tests that might be relevant to understanding the needs of an athlete:

Test/assessment	Relevant information
Fitness assessment	1.
	2.
	3.
	4.
	5.
	6.
Blood tests	1.
	2.
	3.
	4.
	5.
Medical assessments	1.
	2.
	3.
	4.
	5.
	6.

Exercise 10: Psychosocial Influences

What are five examples of social influences that can affect dietary intake?

1.

2.

3.

4.

5.

List five factors that could be influenced by social factors.

1.

2.

3.

4.

5.

What are five self-concept issues that could impact dietary practices?

1.

2.

3.

4.

5.

List three competitive goals and commitments that could impact dietary practices.

1.

2.

3.

Explain factors related to an athlete's attitudes toward life and their philosophy of life that can impact dietary practices.

List and explain the three factors that can impact eating behaviors.

1. ________________
2. ________________
3. ________________

Exercise 11: Nutritional Counseling Strategies

What situation results in the most successful nutritional interventions?

Explain the components of a nutrition care plan and how it is implemented.

Discuss how implementing a dietary change most likely requires a lifestyle change. How might a dietary change result in a change in lifestyle?

List and explain the 10 strategies for counseling an athlete on dietary changes.

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Review Test

1. When performing laboratory tests on an athlete, all of the following might be useful blood tests except:
   a. Complete blood count
   b. Blood pressure analysis
   c. Iron status assessment
   d. Assessment of food allergies

2. If a coach tells an athlete that they are fat and that athlete develops a negative body image, what psychosocial influences have they experienced?
   a. Self-concept influences
   b. Commitment influences
   c. Social influences
   d. Life philosophy issues
   e. a and b
   f. a and c

3. All of the following causes of death are related to dietary excesses except:
   a. Coronary heart disease
   b. Cancer
   c. HIV
   d. Diabetes

4. An athlete's food choices can be significantly affected by the athlete's school or work schedule.
   a. True
   b. False

5. The collection of __________ is (are) useful in determining the athlete's optimal weight.
   a. Percent body fat
   b. Current weight
   c. Height
   d. All of the above

6. One of the most common field methods for estimating body composition is the BMI.
   a. True
   b. False

7. The respiratory exchange ratio represents the amount of carbohydrates and lipids oxidized at the cellular level.
   a. True
   b. False

8. All of the following are true about the BMI assessment technique except:
   a. A very lean muscular athlete will sometimes be classified as overfat
   b. The BMI technique is simple because it only requires height and weight to estimate the athlete's fatness
   c. The BMI assessment technique is one of the most accurate methods of determining body composition
   d. A small endurance runner could be classified as underweight

9. When using bioelectrical impedance analysis systems to estimate body composition, the tester should make sure the athlete:
   a. Avoids intense exercise for a minimum of 12 hours before the test
   b. Consumes no alcohol for at least 12 hours before the test
   c. Empties the bladder within 60 minutes of the assessment
   d. a and b
   e. b and c

10. If Janna wants to have a body fat of 14%, she weighs 160 pounds, and her body fat is 25%, what is her optimal body weight?
   a. 128 pounds
   b. 149 pounds
   c. 130 pounds
   d. 110 pounds

11. If Mark weighs 180 pounds, has a body fat of 14%, and wants to decrease his body fat to 12%, all of the following are true except:
   a. Mark currently has 25.2 pounds of body fat
   b. Mark has a total lean body mass of 154.8 pounds
   c. Mark needs to lose 3 pounds of fat to reach his optimal weight goal
   d. Mark will have a total of 21.1 pounds of fat at his optimal weight level

12. The method by which an individual has their energy expenditure determined by measuring the amount of heat given off by the body is considered a form of indirect calorimetry.
   a. True
   b. False

13. All of the following are considered examples of methods of estimating energy needs with mini, portable devices except:
    a. Skin temperature assessment
    b. Galvanic skin response assessment
    c. Heat flux assessment
    d. Indirect calorimetry.

14. If Phoebe is 27 years old, weighs 65 kg, and is 160 cm tall, her resting metabolic rate could be estimated to be:
    a. 1446 kcal
    b. 2000 kcal
    c. 1666 kcal
    d. None of the above

15. Considering your answer to question 14, if Phoebe were active, her total caloric needs would be __________ kcal.
    a. 2009
    b. 2155
    c. 2531
    d. 2979

16. If Guy is 52 years old and has a body fat of 25%, you would classify him as:
    a. Being obese
    b. Having a low body fat
    c. Having a mid-range body fat level
    d. Having too little body fat

17. If Randy is 145 pounds and has a body fat of 12%, all of the following are true except:
    a. He has 174 pounds of fat on his body
    b. His resting metabolic rate is 1775 kcal
    c. His lean body mass is 127.6 pounds
    d. His resting metabolic rate is 3300 kcal

18. If a clinician needs to assess the food intake, activity, and mood of an athlete, they should select which of the following assessment tools:
    a. Food frequency form
    b. Food diary
    c. Food and activity record
    d. 24-hour dietary recall

19. One of the best ways to counsel an athlete about their diet is to berate them for not knowing the correct dietary recommendations.
    a. True
    b. False

20. To truly help an athlete with their diet, the clinician needs to assess the barriers that could impede the athlete from making a specific lifestyle change.
    a. True
    b. False

Review of Terminology

Basic Principles	**Nutritional Assessment Strategies**	**Determination of Caloric Requirements**
Anthropometric	Bioelectrical Impedance Assessment	Calorie Deficit
Dietary	Body Composition	Direct Calorimetry
Nutritional Assessment	Body Mass Index	Harris-Benedict Equation
	Circumference Assessment	Indirect Calorimetry
	Height	Respiratory Exchange Ratio
Dietary Assessment Tools	Optimal Body Weight	Respiratory Quotient
Nutrition Questionnaire	Skinfold Assessment	
24-Hour Recall	Weight Analysis	
Food Frequency Form		
Food Diary	Fitness and Laboratory Tests	
Food and Activity Record	Blood Lipids	
	Blood Pressure	
	Body Fat Percent	
	Complete Blood Count	
	Comprehensive Metabolic Panel	
	Flexibility	
	Food Allergy	
	Heart Rate	
	Iron Status	
	Strength	

Important Abbreviations

BIA	CMP
BMI	RER
CBC	RQ

Part III
Basic and Applied Nutrition

11
An Overview of Macronutrients

Objectives

On the completion of this chapter, you will be able to:

1. Understand the differences among monosaccharides, oligosaccharides, and polysaccharides.
2. Explain the glycemic index and glycemic loads of a variety of carbohydrate sources.
3. Describe the health benefits of having high-fiber content in the diet.
4. Present sources of soluble and insoluble fiber.
5. Give examples of monosaccharides, oligosaccharides, and polysaccharides.
6. Describe the three major forms of fat.
7. Explain what linolenic and linoleic acids are.
8. Discuss what trans fatty acids are and why they are unhealthy.
9. Present the major functions of carbohydrates, fats, and proteins in the body.
10. Describe the different sources of fat in the body and give dietary examples.
11. Differentiate between essential and nonessential amino acids.
12. Understand what is meant by biologic value.
13. Give examples of food combinations that offer complete proteins.
14. Explain the basics of protein metabolism.

Learning Exercises

Exercise 1: Carbohydrates

List and define the three major classifications of carbohydrates.

1.

2.

3.

____________ are also referred to as simple sugars.

Sucrose is composed of ___________ and _____________.

Long chains of ____________ comprise ___________ and are often referred to as complex carbohydrates.

List and describe the two major forms of complex carbohydrates:

1.

2.

_________ is a storage form of carbohydrates in plants, and is the most digestible form of plant polysaccharides.

____________ has the ability to dissolve in water to form a gel or paste.

____________ tends to absorb water, which increases its bulk, allowing it to make a large contribution to the volume of feces.

Increases in dietary fiber have been linked to three health benefits:

1.

2.

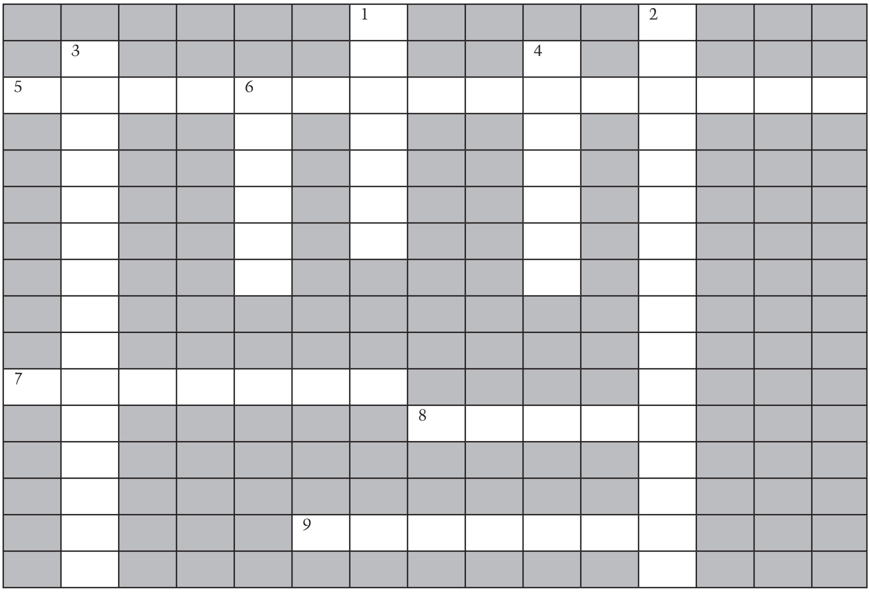
3.

Fill in the type of fiber associated with each of the following dietary sources:

Wheat ____________ Bran ____________ Fruits ____________

Rice ____________ Oats ____________ Peas ____________

Fill in the following crossword puzzle:



Across:

5. Dextrose is an example of this type of carbohydrate
7. Also known as malt sugar
8. Can be classified as soluble or insoluble
9. An example of a monosaccharide and is the simplest form of carbohydrate

Down:

1. Also known as table sugar
2. Are composed of short-chain monosaccharides that are joined together
3. Starch and fiber are examples of this type of carbohydrate
4. Also known as milk sugar
6. The most common form of digestible plant polysaccharides

What are three primary functions of carbohydrates?

1.

2.

3.

Explain what the glycemic index is and how it is determined. What are some examples of foods with a high glycemic index?

Explain what the glycemic load is and how it is determined.

The higher the glycemic load, the __________ the expected increase in blood glucose.

High-fiber foods generally have a ________ glycemic index.

Low-fiber foods generally have a ________ glycemic index.

Fill in the following table:

	Glycemic index	**Glycemic load**
High		
Medium		
Low		

Polysaccharides must be hydrolyzed to ______________ before they can be absorbed from the ________________ into the blood stream.

The storage form of carbohydrates is termed ___________. Generally, carbohydrates are stored in the _________ and __________.

The main source of carbohydrates in the human diet comes from ________________.

What are three examples of monosaccharides?

1.

2.

3.

Milk sugar is an example of ___________ and is made by joining glucose and ________.

___________ is also known as fruit sugar and can be found in _________ and ______.

What are three examples of oligosaccharides and disaccharides?

1.

2.

3.

What are the dietary recommendations for fiber?

1. Men and women <50 years:

2. Men and women >50 years:

Exercise 2: Fat

What are the three major types of fats?

1.

2.

3.

What two polyunsaturated fats must humans ingest because they cannot make them?

1.

2.

What are three examples of deficiency that occur when insufficient amounts of essential fatty acids are consumed?

1.

2.

3.

__________ is not an essential dietary component because it can be synthesized in the liver.

Explain the difference between low-density and high-density lipoproteins.

___________ are the most significant source of dietary fat and are composed of _________ and ___________.

__________ are also known as triacylglycerols.

Explain how trans fatty acids are similar to saturated fats.

Explain the health consequences of consuming high levels of trans fatty acids and saturated fats in the diet.

What are five examples of health consequences associated with high levels of trans fatty acid and saturated fat consumption?

1.

2.

3.

4.

5.

What are the six major functions of fats in the body?

1.

2.

3.

4.

5.

6.

What are three places where triglycerides are stored?

1.

2.

3.

Match the type of fat with the source.

____________	Herring	A.	Trans fat
____________	Butter	B.	Polyunsaturated
____________	Pastries	C.	Saturated
____________	Cream	D.	Monounsaturated
____________	Soy		
____________	Avocados		
____________	Fried foods		
____________	Canola		
____________	Coconut		
____________	Meat		
____________	Peanut oil		

Match the type of fat with the recommended daily amounts.

____________	Monounsaturated	A.	As little as possible
____________	Saturated	B.	10%–15% of calories
____________	Trans fat	C.	Up to 10% of calories
____________	Polyunsaturated		

Exercise 3: Protein

What are the nine essential amino acids?

1.

2.

3.

4.

5.

6.

7.

8.

9.

What are the 11 nonessential amino acids?

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.

What are the three branched-chain amino acids?

1.
2.
3.

What is unique about branched-chain amino acids in comparison to other essential amino acids?

What are two benefits of consuming branched-chain amino acids before and after exercise?

1.
2.

What are the six major functions of proteins in the body?

1.
2.
3.
4.
5.
6.

The ingestion of proteins supplies a source of essential amino acids that yield the ________ needed for the synthesis of nonessential amino acids.

________ is the process by which amino acids lose their nitrogen molecule in the liver, which results in the formation of urea.

What does the process of transamination involve?

An acceptor amino acid is termed a ________

Describe in detail what happens when dietary intake of protein is inadequate.

Define what is meant by biologic value.

Explain what is meant by complete and partially complete proteins? What makes them differ?

Give nine examples of combinations of plant proteins that can create a complement of complete proteins.

1.

2.

3.

4.

5.

6.

7.

8.

9.

What is the only plant source of protein that yields a complete complement of essential amino acids?

____________ of protein contain all the essential amino acids.

Review Test

1. Glucose is an example of a(n):
   a. Monosaccharide
   b. Polysaccharide
   c. Disaccharide
   d. Oligosaccharide

2. Malt sugar is composed of __________ and __________.
   a. Glucose, fructose
   b. Glucose, glucose
   c. Glucose, galactose
   d. Fructose, galactose

3. Beer contains:
   a. Fructose
   b. Maltose
   c. Lactose
   d. Pectin

4. Which food has the highest glycemic index value?
   a. Apple
   b. Wheat bread
   c. Cola
   d. Pancakes

5. Which food has the lowest glycemic load?
   a. Skim milk
   b. Bagel
   c. Sweet potato
   d. Banana

6. All of the following are functions of carbohydrates in the body except:
   a. Facilitates the metabolism of fat
   b. Provides energy for the brain
   c. Serves as a transporter for vitamin A
   d. Spares muscle proteins

7. Fiber has been found to offer numerous health benefits including:
   a. Lowers blood glucose levels
   b. Normalizes blood cholesterol levels
   c. Prevents the occurrence of dermatitis
   d. a and b
   e. a and c

8. All of the following are sources of insoluble fiber except:
   a. Wheat
   b. Oats
   c. Bran
   d. a and b
   e. b and c

9. The storage form of carbohydrates in the body is:
   a. Glycogen
   b. Amino acids
   c. Free fatty acids
   d. Glucose

10. Triglycerides are also known as:
    a. Cholesterols
    b. Trans fatty acids
    c. Triacylglycerols
    d. Linoleic acids

11. Fats that contain one carbon–carbon double bond are called:
    a. Saturated
    b. Monounsaturated
    c. Polyunsaturated
    d. Complete

12. Omega-3 fatty acids are also known as:
    a. Trans fatty acids
    b. Linoleic acids
    c. Triacylglycerols
    d. Linolenic acids

13. Diets that are high in linolenic acid tend to increase the risk of cardiovascular disease.
    a. True
    b. False

14. Trans fatty acids are considered to behave similar to:
    a. Unsaturated fats
    b. Linolenic acids
    c. Saturated fats
    d. All of the above

15. All of the following are functions of fat in the body except:
    a. The most energy-dense molecule in the body
    b. Assists in carbohydrate metabolism
    c. Delays hunger pains
    d. Critical for signal transmission.

16. All of the following are sources of omega-3 fatty acids except:
    a. Tuna
    b. Walnuts
    c. Sardines
    d. Avocados

17. ___________ is an example of a nonessential amino acid that is a branched-chain amino acid.
    a. Histidine
    b. Lysine
    c. Valine
    d. Threonine

18. Proteins contribute to all of the following except:
    a. Antibodies for the immune system
    b. Fuel source when glycogen levels are high
    c. Contractile protein structure
    d. Transport protein content

19. The combination of lentils and bread supplies a complete complement of amino acids.
    a. True
    b. False

20. All of the following have a high biologic value except:
    a. Chicken breasts
    b. Scrambled eggs
    c. Peanut butter
    d. Cottage cheese

Review of Terminology

Carbohydrates	**Fat**	**Protein**
Monosaccharides	Adipose Tissue	Amino Acids
Oligosaccharides	Cholesterol	Biologic Value
Polysaccharides	Essential Fatty Acids	Branched-Chain Amino Acids
Starch	Glycerol	Deamination
Fiber	High-Density Lipoproteins	Essential Amino Acids
Glycemic Index	Linoleic Acid	Isoleucine
Glycemic Load	Linolenic Acid	Keto-Acid
Glucose	Lipid	Leucine
Fructose	Low-Density Lipoproteins	Nonessential Amino Acids
Galactose	Monounsaturated Fat	Proteins
Sucrose	Omega-3 Fatty Acid	Transamination
Lactose	Omega-6 Fatty Acid	Valine
Maltose	Polyunsaturated	
Dextrose	Saturated Fatty Acids	
Sugar	Trans Fatty Acids	
Dextrin	Triacylglycerols	
Cellulose	Triglycerides	
Hemicellulose		
Pectin		

Important Abbreviations

ACTH	EFA
ADH	GI
BCAA	GL
BV	HDL
DRI	LDL

12
Protein

Objectives

On the completion of this chapter, you will be able to:

1. Understand the basics functions of proteins in the body.
2. Describe the components of the amino acid pool.
3. Discuss the process by which proteins are digested and absorbed into the body.
4. Differentiate among essential, conditionally essential, and nonessential amino acids.
5. Understand the difference between complete and incomplete protein sources.
6. Discuss the three major methods for quantifying protein quality.
7. Describe the recommended protein needs for various populations.
8. Contrast the effects of increasing protein intake on adaptations that occur in response to a resistance training program.
9. Describe the effects of consuming various types of proteins on muscle proteins synthesis.
10. Understand the importance of protein timing and its relationship to adaptive responses.
11. Discuss the potential hazards of high protein diets and determine if these risks are exaggerated.

Learning Exercises

Exercise 1: Overview of Protein and Amino Acid Metabolism

List and describe the eight functional roles of protein:

1. ___________________:
2. ___________________:
3. ___________________:
4. ___________________:
5. ___________________:
6. ___________________:
7. ___________________:
8. ___________________:

Exercise 2: Protein Basics

What differentiates protein from the other macronutrients?

What are the four major components of the amino acid pool?

1.
2.
3.
4.

Most proteins are ___________ that are composed of >100 amino acids that are linked together.

Describe the following terms:

1. Nitrogen balance (status):
2. Negative nitrogen balance (status):
3. Positive nitrogen balance (status):

Exercise 3: Digestion and Absorption

Where does protein digestion begin?

Fill in the components of the equation for the formation of pepsin:

______________________ + ________________ = pepsin

What is the function of pepsin?

What are the four major enzymes of the pancreas?

1.

2.

3.

4.

What are the two enzymes of the brush border?

1.

2.

Which three enzymes are considered endopeptidases that hydrolyze peptide bonds within chains?

1.

2.

3.

What two enzymes are considered exopeptidases that act on amino acids N or C terminus?

1.

2.

Amino acids are absorbed from the ________________ into the blood via the use of a sodium-dependent cotransporter and/or facilitated diffusion.

What compound interacts with amino acids which are transported to the intestine and kidneys? What does it facilitate?

What interacts with protein in the large intestine that is not absorbed? What are the two compounds that are created?

__________ of ingested plant proteins and ____________ ingested animal proteins can be digested by humans.

What are three possible destinations for amino acids once they enter the amino acid pool?

1.

2.

3.

Explain what transamination is. What does it do?

In transamination reactions, what two things are required?

1.

2.

What are the two most common transaminase reactions?

_____________ + _____________ ⇔ ____________ + ______________

Enzyme: ________________

_____________ + _____________ ⇔ ____________ + ______________

Enzyme: ________________

ALT = _____________________ which was formerly known as _______________

AST = _____________________ which was formerly known as _______________

ALT and AST are often used as clinical markers of ________________, which could be indicative of ____________.

Explain what might happen to ALT and AST in response to intense training.

What are the three steps associated with oxidative deamination?

1.

2.

3.

What is the urea cycle?

What are three major excretory products that are generated from protein?

1.

2.

3.

__________ excretion is relatively constant and is often used as an indirect measure of muscle mass.

Exercise 4: Food Sources of Protein

What determines if a protein is considered a complete protein?

What are the nine essential amino acids?

1.	2.	3.	4.	5.
6.	7.	8.	9.	

List five examples of complete proteins.

1.

2.

3.

4.

5.

What determines if a protein is considered incomplete?

List the 11 nonessential amino acids.

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.

What are four examples of incomplete proteins?

1.
2.
3.
4.

Define the following terms:

1. Essential:
2. Conditionally essential:
3. Nonessential:

What are the five conditionally essential amino acids?

1.
2.
3.
4.
5.

Match the food choice with its corresponding protein content.

1. ________ 8-oz. glass of milk — A) 20 g of protein
2. ________ 1-oz. serving of chicken — B) 2 g of protein
3. ________ 1 slice of wheat bread — C) 3 g of protein
4. ________ 1/2 cup mixed vegetables — D) 8 g of protein
5. ________ 1 scoop of protein powder — E) 7 g of protein

Exercise 5: Methods of Measuring Protein Quality

List and describe the three most common methods for determining protein quality:

1. ____________________:
2. ____________________:
3. ____________________:

Fill in the missing information in the following table:

Protein source	BV	PER	PDCAAS
Hydrolyzed whey		>3.0	
Whey concentrate	100		1.00
Whole egg		2.8	
Milk	91		
Beef/poultry, fish			0.8–0.92
Soy	74		
Casein			1.00

Exercise 6: Protein Requirements

List three methods that are used to study protein metabolism:

1.
2.
3.

Explain what the nitrogen balance method measures. How is this determined?

The recommended daily allowance (RDA) for protein is based on the __________ technique.

Describe the following conditions:

1. Nitrogen status:
2. Positive nitrogen status:
3. Negative nitrogen status:

What subject population is the RDA generally based on?

Match the following categories of individuals with the recommended protein intakes.

1. ________	Sedentary (adult)	A) 1.0–1.4 g/kg
2. ________	Recreational exerciser (adult)	B) 1.4–2.0 g/kg
3. ________	Resistance trained (maintenance)	C) 0.8 g/kg
4. ________	Resistance trained (gain muscle mass)	D) 1.2–1.4 g/kg
5. ________	Endurance trained	E) 1.2–1.8 g/kg
6. ________	Intermittent, high-intensity training	F) 1.4–1.8 g/kg
7. ________	Weight-restricted sports	

How much more protein should be added to the dietary practices of growing teens?

If one athlete consumed 1.2 g/kg of protein and another consumed 2.1 g/kg, which athlete would you suspect would gain more lean body mass?

Compare and contrast the effects on whole-body protein synthesis in response to consuming 0.9, 1.4, and 2.4 g/kg a day of protein.

Explain the potential differences in protein metabolism in regard to nitrogen balance and leucine oxidation in male and female endurance runners who are consuming between 0.8–0.9 g protein/kg a day.

Exercise 7: Protein Type

Vegetarian diets are ___________ to diets based on animal products in their capacity to promote strength and body composition gains.

Soy protein is considered to be __________ to milk proteins in their capacity to promote strength and conditioning gains.

Rank the following dietary components by their effect on protein synthesis (1 = highest, 5 = lowest):

1. __________ Carbohydrates
2. __________ Essential amino acids and carbohydrates
3. __________ Mixed amino acids
4. __________ Essential amino acids
5. __________ Mixed amino acids and carbohydrates

Does adding nonessential amino acids to a supplement that contains essential amino acids change the amount of muscle protein synthesis stimulated?

What are the effects of consuming branched-chain amino acids on weight loss?

Exercise 8: Timing of Protein Intake

If one athlete were to ingest a carbohydrate + protein beverage before training and another would only ingest this same beverage after exercise, who would have the highest net protein synthesis rate?

If you were consulting an athlete and they asked if they should 1) consume a protein supplement immediately after training, or 2) consume a protein supplement 2 hours after training, what would you recommend? Why?

If you were to consume 25 g of protein immediately before and after a training session for a 14-week cycle of training, how much more muscle hypertrophy would you expect to see if you compared this supplement regime to a carbohydrate supplement that is taken in the same supplement scheme?

What are five effects that have been noted in Marines who consume a postexercise protein supplement?

1.

2.

3.

4.

5.

Exercise 9: Safety Aspects of Protein Diets

What are the five risks that are often reported as adverse effects to high-protein diets? Why might these risks be exaggerated?

1.

2.

3.

4.

5.

Review Test

1. Which compound is not found in carbohydrate or fat, but is present in protein?
   a. Nitrogen
   b. Carbon
   c. Hydrogen
   d. Oxygen

2. Which of the following are functional roles of protein?
   a. Proteins can be degraded to amino acids which can be used to form glucose
   b. Proteins can be used to form enzymes
   c. Proteins are found in muscles, bones, and tendons
   d. All of the above

3. The amino acid pools of the body contain:
   a. The liver
   b. The skeletal muscle
   c. The skeletal system
   d. a and c
   e. a an b

4. When an athlete is increasing their lean body mass, they are likely in:
   a. Nitrogen balance
   b. Negative nitrogen status
   c. Positive nitrogen status
   d. None of the above

5. What enzyme cleaves peptide bonds that link amino acids together?
   a. Endopeptidase
   b. Pepsin
   c. Aminopeptidase
   d. Elastase

6. All of the following are endopeptidases except:
   a. Trypsin
   b. Pepsin
   c. Chymotrypsin
   d. Elastase

7. It is widely accepted that 85% of animal proteins and 95% of plant proteins are absorbed in humans.
   a. True
   b. False

8. All of the following are enzymes from the pancreas except:
   a. Aminopeptidase
   b. Intracellular peptidase
   c. Carboxypeptidase

9. Which of the following amino acids are considered branched-chain amino acids?
   a. Leucine
   b. Arginine
   c. Glycine
   d. Serine

10. The usual end product of a transamination reaction is:
    a. alpha-Ketoglutarate
    b. NH_3^+
    c. Glutamate
    d. Vitamin B6

11. Which amino acids cannot undergo transamination?
    a. Leucine
    b. Lysine
    c. Threonine
    d. a and b
    e. b and c
    f. a and c

12. The concentration of alanine aminotransferase can be used as a clinical marker of hepatocellular injury.
    a. True
    b. False

13. What is the effect of high-intensity training on AST and ALT concentrations?
    a. No effect
    b. Increase
    c. Decrease

14. The excretion of ________ is relatively constant and is directly related to muscle mass.
    a. Urea
    b. Uric acid
    c. Creatinine
    d. All of the above

15. Plant sources of protein are considered to be superior to animal sources when looking at the promotion of strength gains.
    a. True
    b. False

16. Which protein source has the highest protein efficiency ratio?
    a. Whole eggs
    b. Soy
    c. Casein
    d. Whey concentrate

17. Chuck is an Iron Man triathlete. His protein recommendations would be:
    a. 1.2–1.4 g per kg body mass
    b. 0.8 g per kg body mass
    c. 1.4–1.8 g per kg body mass
    d. 1.4–2.0 g per kg body mass

18. Consuming 2.4 g of protein per kg body mass while undertaking a resistance training regime results in __________ whole-body protein synthesis compared with consuming 0.9 g of protein per kg body mass.
    a. No measurable difference in
    b. An increased
    c. A decreased

19. Which type of supplement results in the highest net phenylalanine uptake?
    a. Carbohydrate only
    b. Mixed amino acids
    c. Essential amino acids
    d. Essential amino acids and carbohydrates

20. All of the following are effects of consuming a postexercise protein supplement except:
    a. Decreased protein synthesis
    b. Reduced muscle soreness
    c. Reduction in the occurrence of viral infections
    d. Increased muscular strength

Review of Terminology

Protein Basics	**Digestion and Absorption**	**Food Sources of Protein**
Nitrogen	Alanine Aminotransferase	Alanine
Nitrogen Balance	Aminopeptidases	Arginine
Nitrogen Status	Aspartate Aminotransferase	Asparagine
Negative Nitrogen Status	Carboxypeptidase	Aspartic Acid
Positive Nitrogen Status	Chymotrypsin	Branched-Chain Amino Acids
Polypeptides	Creatinine	Complete Protein
	Elastase	Conditionally Essential
Protein Requirements	Endopeptidases	Cysteine
Isotropic Tracers	Glutamate	Essential Amino Acids
Negative Nitrogen Status	Glutamate-Oxaloacetate Transaminase	Glutamic Acid
Nitrogen Balance	Glutamate-Pyruvate Transaminase	Glutamine
Nitrogen Status	Glutathione	Glycine
Positive Nitrogen Status	Hepatocellular Injury	Histidine
Recommended Daily Allowance	Hydrochloric Acid	Isoleucine
	Intracellular Peptidases	Lysine
	Isoleucine	Methionine
	Leucine	Nonessential Amino Acids
	Lysine	Phenylalanine
	Methane	Proline
	Nucleic Acids	Serine
	Oxidative Deamination	Threonine
	Pepsin	Tryptophan
	Pepsinogen	Tyrosine
	Threonine	Valine
	Transaminase	
	Transamination	
	Trypsin	
	Urea	
	Uric Acid	
	Valine	

Important Abbreviations

ALT	MAA
AST	PDCAAS
BCAA	PER
BV	RDA
CHO	SGOPT
EAA	SGOTT

13
Fat

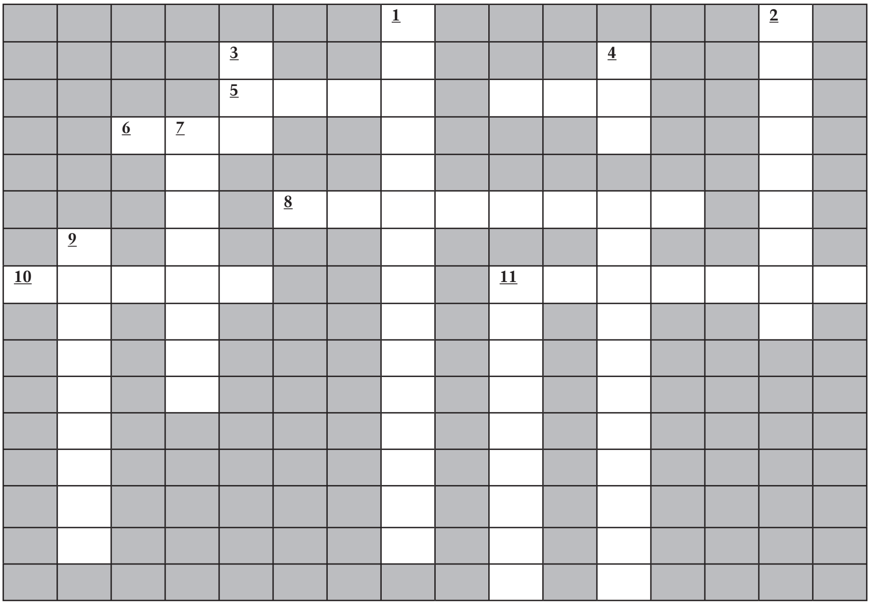
Objectives

On the completion of this chapter, you will be able to:

1. Define the major types of fatty acids and relate them to specific food examples.
2. Understand the process by which fat is metabolized.
3. List the steps involved in the metabolism of fatty acids.
4. Describe omega-3, omega-6, and trans fats and their relationship to health and wellness.
5. Discuss the seven potential athletic benefits of manipulating dietary fat content.
6. Explain the relationship between respiratory exchange ratio and respiratory quotient.
7. Discuss the role of fat as a fuel during resting and low-intensity exercise conditions.
8. Understand the effects of high-intensity exercise on fat metabolism.
9. Explain the effect of intensity and duration of exercise on fat metabolism.
10. Understand the effects of increasing exercise intensity on fat metabolism.
11. Explain the two major methods of manipulating dietary fat in an attempt to induce an ergogenic effect.

Learning Exercises

Exercise 1: Fat Biochemistry—Basic Definitions



Across:

5. A class of compounds consisting of triglycerides, sterols, and phospholipids
6. A fatty acid that contains 20 carbons and 5 carbon double bonds
8. A three-carbon molecule that helps form the larger triacylglycerol molecule
10. A fatty acid found in olive oil
11. A fatty acid found in beef fat

Down:

1. Formerly known as triglycerides
2. A fatty acid found in flax oil
3. A dairy fat with 18 carbons and two carbon double bonds
4. Creation of new glucose
7. A fatty acid with 16 carbons and no carbon double bonds
9. Chains of carbon atoms
11. Contains no double bonds

Exercise 2: Dietary Fat

__________ is the kilocalorie-dense compound that makes up the vast majority of dietary lipids.

In detail, describe what a medium-chain triacylglycerol molecule is.

How many kilocalories do lipids contain? ___________

Place the following steps of digestion, absorption, and storage of TAG in order (1 = first, 12 = last):

__________ Placed into cells

__________ Taken to the stomach

__________ Goes to the thoracic duct

__________ Goes to the duodenum (bile, pancreatic lipase)

__________ Goes to the villi

__________ Is placed in chylomicron packaging

__________ Enters the mouth and is acted on by lingual lipase

__________ Goes to the ileum

__________ Goes through the large blood vessels

__________ Goes to the enterocytes

__________ Goes to the lymphatic system

__________ Enters the capillaries (lipoprotein lipase)

Match the following terms with the appropriate definitions:

________ Lipolysis	A) Enzyme that interacts with chylomicrons
________ Oxidation	B) Fat breakdown
________ Lipogenesis	C) Fat cells
________ Adipocytes	D) Burning of fat
________ Myocytes	E) Fat storage
________ Lipoprotein lipase	F) Muscle cells

Exercise 3: Pharmacology and Essentiality

Explain what makes fats different than other major macronutrients.

What are some factors that influence the pharmacologic effects of fatty acids?

What are the two essential fatty acids that humans cannot make?

1.

2.

What enzyme do humans lack that does not allow them to create carbon–carbon double bonds beyond the C_9 position?

What type of fatty acid is considered to be proinflammatory and present in large quantities in Western diets?

Discuss the ratio of omega-6 to omega-3 fatty acids that is considered healthy. Is the current ratio of omega-6 to omega-3 fatty acids close to this ratio in the typical Western diet?

Explain what a trans fatty acid is and how it differs from a cis version of these fats. In this discussion, explain some of the negative effects of trans fatty acids on the body.

Exercise 4: Resting Fat Metabolism

When an individual is in a fasting condition and they are at rest, __% of calories come from the metabolism of fat.

Explain why we would not just lounge around to maximize our metabolism of fat?

What is the respiratory exchange ratio? What does it represent?

What is the equation for the respiratory exchange ratio?

RER = ___________

An RER of 0.79 is indicative of what?

An RER of 1.0 is indicative of what?

What are two factors that account for an increase in RER toward 1.0?

1.

2.

Exercise 5: Fat Metabolism—Exercise

When examining the RER during very intense exercise, one would expect the RER to ___________.

List two examples of physiologic adaptations that allow athletes to better metabolize or increase the ability to metabolize fats as a fuel:

1.

2.

Fat use and exercise duration are ___________ related.

Fat use and exercise intensity are ___________ related.

What happens to the glycerol content of the blood over a long period of exercise when blood samples are taken every 10–20 minutes? How does this correspond to the changes in RER observed?

The increase in RER associated with high-intensity anaerobic exercise signifies what?

1.

2.

What compound is part of the blood buffer system and is used to counteract the acidity that is generated from very intense exercise?

When exercise is very intense, what happens to fat metabolism? Why does this happen?

When total kilocalorie expenditure is controlled, does it really matter if you do high- or low-intensity exercise? Why?

Exercise 6: Athletic Enhancement with Dietary Fat Manipulations

Describe the two major forms in which manipulations in dietary fat have been used in order to achieve an ergogenic effect:

1. Fat loading:
2. Altering fat type:

How does manipulating fat content in the diet affect:

1. Cortisol:
2. C-reactive protein:
3. Interleukin-6:

List the seven potential benefits of manipulating dietary fat content.

1.
2.
3.
4.
5.
6.
7.

Review Test

1. ________ is a three-carbon molecule that provides the backbone for the larger triacylglycerol molecules.
   a. Fatty acid
   b. Lipid
   c. Glycerol
   d. All of the above

2. Lipids are a class of compounds that contain:
   a. Triacylglycerols
   b. Sterols
   c. Phospholipids
   d. All of the above

3. Which of the following food sources contains linoleic acid?
   a. Corn oil
   b. Eicosapentaenoic acid
   c. Olive oil
   d. Beef fat

4. A fatty acid that contains one double bond is termed a ________ fat.
   a. Saturated
   b. Monounsaturated
   c. Polyunsaturated
   d. Trans

5. Triacylglycerol was formerly referred to as a triglyceride.
   a. True
   b. False

6. Place the following steps of fat digestion in order.
   i. Duodenum (bile, pancreatic lipase)
   ii. Mouth
   iii. Villi
   iv. Stomach
   v. Ileum

   a. iv, i, ii, v, iii
   b. ii, i, v, iii, iv
   c. ii, iv, i, v, iii
   d. iii, i, v, ii, iv

7. Which of the following would be considered to be an essential fatty acid?
   a. Oleic acid
   b. Conjugated linoleic acid
   c. Palmitic acid
   d. Linolenic acid

8. The metabolism or breakdown of fat is termed:
   a. Lipogenesis
   b. Lipolysis
   c. Oxidation
   d. None of the above

9. The ratio of omega-6 to omega-3 fatty acids that should be in the diet should be:
   a. 7 : 1
   b. 20 : 1
   c. 1 : 20
   d. 1 : 7

10. Trans fatty acids have been linked to the following:
    a. Heart disease
    b. Inflammation
    c. Lung cancer
    d. a and b
    e. b and c

11. All of the following are potential athletic benefits of manipulating dietary fat except:
    a. Reduced inflammation and breakdown of soft tissue
    b. Increased catabolic hormone concentrations
    c. Correction of inadequate energy status
    d. Maintenance of sex hormone concentrations

12. The RER for carbohydrate metabolism is:
    a. 0.60
    b. 0.79
    c. 0.85
    d. 1.00

13. All of the following are true about the RER except:
    a. The RER is calculated by dividing the VO_2 by the VCO_2
    b. The RER is an indirect calorimetry method that uses gases to calculate energy use
    c. The RER is a laboratory method that uses a metabolic cart
    d. The RER is higher when performing high-intensity anaerobic exercise than when performing aerobic exercise.

14. There is an indirect relationship between fat use and exercise duration.
    a. True
    b. False

15. Which of the following is (are) physical adaptations that enhance an athlete's ability to utilize fat as a fuel:
    a. Increased mitochondrial density
    b. Increased capillarization
    c. a and b
    d. None of the above

16. The creation of new glucose is termed:
    a. Glycolysis
    b. Gluconeogenesis
    c. Lipogenesis
    d. Lipolysis

17. Fat loading has been shown to:
    a. Decrease time to exhaustion
    b. Increase TAG oxidation
    c. Increase lactate production
    d. Increase the RPE

18. Some studies suggest that including fish oil in the diet can result in an increase in the release of C-reactive protein.
    a. True
    b. False

19. The consumption of 7.2 g of fish oil a day has been shown to decrease the release of cortisol in response to mental stress.
    a. True
    b. False

20. The unhealthy trans fatty acid that is related to commercial cooking procedures is:
    a. Linolenic acid
    b. Oleic Acid
    c. Linoleic acid
    d. Elaidic Acid

Review of Terminology

Fat Biochemistry	Dietary Fat	Pharmacology and Essentiality
Aliphatic Chains	Adipocytes	Desaturase Enzyme
Conjugated Linoleic Acid	Chylomicrons	Elaidic Acid
Docosahexaenoic Acid	Diacylglycerols	Trans Fatty Acid
Eicosapentaenoic Acid	Lipogenesis	
Essential Fatty Acids	Lipolysis	**Resting Fat Metabolism**
Fatty Acids	Lipoprotein	Bicarbonate
Gluconeogenesis	Lipoprotein Lipase	Blood Buffer System
Glycerol	Medium-Chain Triacylglycerol	Capillarization
Lipids		Carbon Dioxide
Monounsaturated Fat	**Exercise Fat Metabolism**	Oxygen
Oleic Acid	Active Recovery	
Omega-3 Fatty Acid	Blood Buffer System	**Athletic Enhancement**
Omega-6 Fatty Acid	Gluconeogenesis	Carbohydrate Loading
Palmitic Acid	Glycolysis	Cortisol
Polyunsaturated Fat	Mitochondria Density	C-Reactive Protein
Saturated Fat	Oxidation	Creatine Kinase
Stearic Acid		Cytokine
Trans Elaidic Acid		Fat loading
Triacylglycerol		Interleukin-6
Triglyceride		Medium-Chain Triacylglycerols
		Rating of Perceived Exertion

Important Abbreviations

DHA	RPE
EPA	RQ
HCO_3^-	TAG
LPL	VCO_2
MCT	VO_2
RER	

14 Carbohydrates

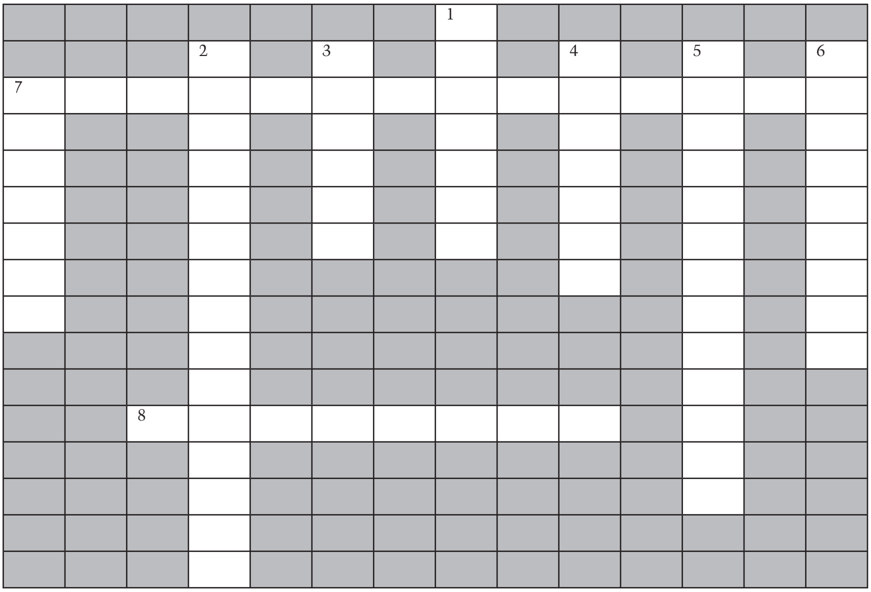
Objectives

On the completion of this chapter, you will be able to:

1. Differentiate among the different types of carbohydrates that are present in the diet.
2. Give examples of the different types of carbohydrates present in the diet.
3. Define the glycemic index and give glycemic index values for selected foods.
4. Define the glycemic load and give glycemic load values for selected foods.
5. Understand the different metabolic pathways associated with the metabolism of carbohydrates.
6. Explain the process by which anaerobic and aerobic exercise bouts are fueled.
7. Discuss why it is important to replenish carbohydrate stores and relate the rate of replenishment to the amount of carbohydrates in the diet.
8. Appreciate the glycogen depletion theory of overtraining.
9. Describe the effects of low carbohydrate diets on anaerobic exercise performance and muscle glycogen stores.
10. Describe the effects of low carbohydrate diets on aerobic exercise performance and muscle glycogen stores.
11. Recommend carbohydrate content needed to meet the exercise demands of athletes who are participating in aerobic and anaerobic training bouts.

Learning Exercises

Exercise 1: Types of Carbohydrates in the Diet



Across:

7. The simplest carbohydrate molecule, contains only one subunit of sugar
8. Also known as levulose

Down:

1. The most common disaccharide
2. Composed of 10 or more monosaccharides that have been bound together
3. Is usually combined with glucose to form lactose
4. Formed from the combination of glucose and galactose
5. Sometimes termed a double sugar
6. An example of a nonstarch polysaccharide
7. Formed by combining two molecules of glucose

What are the three major categories of carbohydrates?

1.

2.

3.

List three possible fates for glucose:

1.
2.
3.

Discuss how high fructose corn syrup relates to obesity.

What are the three major disaccharides?

1.
2.
3.

What is lactose intolerance, and how prevalent is it in different populations?

What is maltose, and where is it most often found?

List some sources of amylose and amylopectin:

1.
2.
3.
4.
5.
6.
7.
8.
9.

What are the major sources of nonstarch polysaccharides?

1.
2.
3.
4.
5.

What is glycogen? How much is stored in the average 70-kg man? How much energy does this supply?

Exercise 2: The Glycemic Index

Describe what the glycemic index is and how was it determined.

The reference food for the glycemic index is _________ or __________, which received an arbitrary number of 100.

How does the rate of digestion of a carbohydrate impact the glycemic index?

List four factors that impact the rate of digestion for a particular food:

1.
2.
3.
4.

A diet centered on low glycemic index foods might be useful for the prevention of what four diseases?

1.
2.
3.
4.

Exercise 3: Glycemic Load

Define what is meant by the glycemic load? What does it represent?

The glycemic load is an independent predictor of what diseases?

1.
2.

Exercise 4: Carbohydrate Metabolism

____________ is the metabolic pathway that results in the breakdown of blood glucose.

____________ is the process by which glycogen stores are broken down.

What are the two anaerobic energy systems used in the metabolism of carbohydrates?

1.

2.

Differentiate between fast and slow glycolysis. What are the end products of each?

How does the ATP yield differ between glucose and glycogen metabolism? Which produces more energy?

Describe the basic process by which carbohydrates are metabolized oxidatively.

Where does aerobic metabolism occur? Is this different than the anaerobic systems?

Which metabolic pathways can only use carbohydrates? Which can use protein? Fat?

Describe the relationship between duration of activity and the reliance on carbohydrates. How does power output relate to carbohydrate metabolism?

What happens to the intensity of an exercise bout as the duration of the activity becomes longer? How does this relate to metabolism?

Acute bouts of resistance training can stimulate a ________% reduction in muscle glycogen stores.

Discuss the fiber-type-specific glycogen utilization patterns. Which types of fibers are preferentially depleted in response to various intensities of resistance training?

List two factors that dictate the amount of glycogen utilized in aerobic exercise bouts:

1.

2.

Relate the intensity of aerobic exercise to muscle glycogen utilization:

1. 30% VO_2 max:
2. 60% VO_2 max:
3. 75% VO_2 max:
4. 70%–100% VO_2 max:

How does muscle glycogen utilization change over the course of a long-duration exercise bout?

How does the intensity of exercise impact the specific fiber-type glycogen utilization patterns?

Is glycogen utilization a limiter to endurance performance?

Does increasing glycogen stores impact aerobic endurance performance?

Exercise 5: Carbohydrate Replenishment

What are the three primary sites where glycogen synthesis occurs?

1.

2.

3.

Describe the basic process by which glycogen is synthesized.

Describe in detail the relationship between dietary intake of carbohydrates and the amount of glycogen stored in the body.

In a classic study, Costill et al. looked at chronic training and two dietary interventions (40% CHO and 65% CHO). How did these two diets relate to muscle glycogen stores?

Sherman et al. also compared a low-carbohydrate diet (27% CHO) and a high-carbohydrate diet (65% CHO). Explain what happened to muscle glycogen stores in these athletes.

Describe the ability of the following to maintain muscle glycogen stores.

1. 8 g $CHO \cdot d^{-1}$:
2. 5 g $CHO \cdot d^{-1}$:

Exercise 6: Glycogen Depletion Theory of Overtraining

Define what is meant by overtraining syndrome.

What are the two categories of overtraining syndrome?

1.
2.

List the five premises that served as the basis for the development of the glycogen depletion theory of overtraining.

1.
2.
3.
4.
5.

Do anaerobic athletes experience significant decreases in glycogen stores? How does this relate to performance and dietary intake of carbohydrates?

What is the typical carbohydrate content of an anaerobic athlete's diet (% CHO)? How does this compare with the general population?

What are the carbohydrate recommendation for_____________ athletes who participate in anaerobic training?

1. Male:
2. Female:

Exercise 7: Low-Carbohydrate Diets and Exercise Performance

How do low- and moderate-carbohydrate diets compare when looking at performance?

What happens to performance if a diet contains <42% carbohydrates?

In what type of events are performance impairments most noted?

How does a low-carbohydrate diet (8%) compare with a moderately high carbohydrate diet when looking at __________?

1. Mean power output:
2. Peak power output:
3. Work output:

List two suggested reasons for the ergolytic effects associated with low-carbohydrate diets:

1.
2.

Exercise 8: Carbohydrate Recommendations for Athletes

Describe the rationale for why carbohydrate intake is an important consideration for the anaerobic athlete.

Outline the carbohydrate recommendations for an anaerobic athlete:

1. Total amount of carbohydrates: ________ $g\,CHO \cdot kg^{-1} \cdot d^{-1}$ ______ %
2. Amount of complex carbohydrates: ___________%
3. Amount of simple carbohydrates: _________%

What type and amount of carbohydrates should be consumed after a high-intensity training bout?

Compare and contrast the daily intake of carbohydrates for male and female endurance athletes.

Male endurance athletes fall _____% below the carbohydrate demands of their training.

Outline the general carbohydrate recommendations for endurance athletes.

List the carbohydrate recommendations for aerobic athletes:

1. Moderate-duration, low-intensity training:
2. Intense endurance training:
3. Extreme endurance training:

What is one way that an athlete can increase the amount of carbohydrates they consume in their diet? How much of the carbohydrate needs should be met with this method?

Review Test

1. This classification of carbohydrates is considered the simplest and only contains one subunit of sugar:
   a. Oligosaccharide
   b. Monosaccharide
   c. Disaccharide
   d. Polysaccharide

2. This monosaccharide is the most common mechanism for transporting carbohydrates in the body:
   a. Glycerol
   b. Lactose
   c. Glucose
   d. Fructose

3. __________ can be used in the process of gluconeogenesis to form glucose in the liver.
   a. Amino acids
   b. Glycerol
   c. Pyruvate
   d. All of the above

4. Recent evidence suggests that the increasing amount of high fructose consumption is related to the obesity epidemic in the United States.
   a. True
   b. False

5. ____________ is a disaccharide that is formed from lactose and glucose.
   a. Maltose
   b. Fructose
   c. Galactose
   d. Lactate

6. What percentage of white Americans are lactose intolerant?
   a. 2%–15%
   b. 6%–22%
   c. 9%–23%
   d. 95%–100%

7. Starch is degraded into maltose by:
   a. α-Amylase
   b. Maltase
   c. Lactase
   d. a and b

8. Amylopectin is a plant polysaccharide that is composed of a linear polymer chain.
   a. True
   b. False

9. ___________ is a food source of amylose and amylopectin.
   a. Corn
   b. Milk
   c. Potatoes
   d. a and b
   e. a and c

10. Nonstarch polysaccharides, such as___________, are not digested in the human stomach or small intestine.
   a. Cellulose
   b. Pectin
   c. Hemicellulose
   d. All of the above

11. Pyruvate is the end product of:
   a. Slow glycolysis
   b. Fast glycolysis
   c. Oxidative metabolism

12. The effect of the Atkin's diet on muscle glycogen stores:
   a. Increased
   b. Decreased
   c. No effect

13. The effect of the Pritikin diet on muscle glycogen stores:
   a. Increased
   b. Decreased
   c. No effect

14. An example of a high glycemic food is:
   a. Peanuts
   b. Cherries
   c. Baguette
   d. Plums

15. Glycogen availability seems to limit performance when the activity lasts:
    a. 15–20 minutes
    b. >60 minutes
    c. <15 minutes
    d. 30–45 minutes

16. Exercise bouts that last around 30 seconds in duration primarily rely on the:
    a. ATP-PC energy system
    b. Oxidative energy system
    c. Glycolytic energy system
    d. None of the above

17. The effect of a diet rich in high glycemic index food sources on the occurrence of Type II diabetes:
    a. Increased
    b. Decreased
    c. No effect

18. The rate of carbohydrate digestion is affected by:
    a. The fat content of the food source
    b. The amount of food consumed
    c. The type of carbohydrate present in the food source
    d. All of the above

19. The effect of increasing the intensity of resistance training on the rate of muscle glycogenolysis:
    a. Increased
    b. Decreased
    c. Unaffected

20. There is an indirect relationship between the amount of carbohydrates in the diet and the amount of glycogen stored in the body.
    a. True
    b. False

Review of Terminology

Types of Carbohydrates	**Carbohydrate Metabolism**	**Carbohydrate Replenishment**
Amylopectin	Aerobic	Glycogen Synthase
Amylose	Anaerobic	Glycogen Synthesis
Cellulose	Fast Glycolysis	Glycogenin
Disaccharide	Glycogenolysis	UDP-Glucose
Fructose	Glycolysis	
Galactose	Krebs Cycle	**Glycogen Depletion Theory of Overtraining**
Gluconeogenesis	Lactic Acid	Overtraining
Glucose	Oxidative Metabolism	Overtraining Syndrome
Glycogen	Oxidative Phosphorylation	
Glycogenolysis	Pyruvate	**Low-Carbohydrate Diets and Exercise Performance**
Gums	Rephosphorylation	Ergolytic
Hemicellulose	Slow Glycolysis	
High Fructose Corn Syrup	Type I	
Homosaccharides	Type II	
Lactose	Type IIab	
Lactose Intolerance	Type IIb	
Maltose		
Monosaccharide		
Mucilages		
Oligosaccharide		
Pectins		
Polysaccharides		
Sucrose		

Important Abbreviations

ADP	GTP
ATP	NADH + H
$FADH_2$	

15
Vitamins and Minerals

Objectives

On the completion of this chapter, you will be able to:

1. Explain the difference between fat-soluble and water-soluble vitamins.
2. Differentiate between macronutrients and micronutrients.
3. Give examples of food groups that supply specific vitamins and minerals.
4. Discuss the specific functions in the body of each vitamin and mineral presented.
5. Understand and be able to explain the current body of scientific knowledge regarding the ergogenic properties of each vitamin and mineral.
6. List the different names associated with each vitamin.

Learning Exercises

Exercise 1: Overview of Vitamins and Minerals

Carbohydrates, fats, and proteins are considered to be _______________.

Vitamins and minerals are classified as ________________.

What are free radicals and when are they produced?

How does the body deal with free radicals?

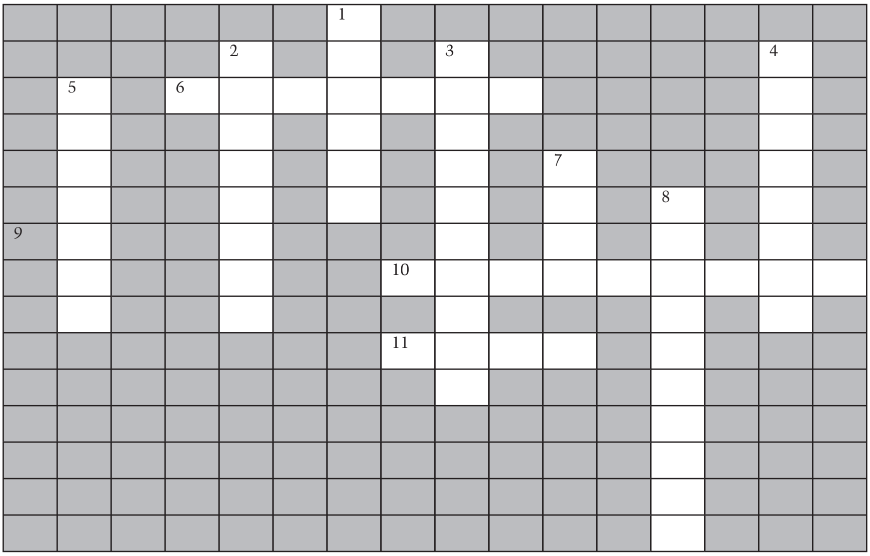
What are some examples of dietary compounds that have the potential to protect against oxidative stress?

Define the following terms:

1. Water-soluble vitamins:
2. Fat-soluble vitamins:

Match the vitamin with an example food source:

1. ____________	Vitamin B6	A) Margarine
2. ____________	Vitamin D	B) Liver
3. ____________	Vitamin E	C) Nuts
4. ____________	Vitamin A	D) Strawberries
5. ____________	Vitamin K	F) Fatty fish
6. ____________	Vitamin C	G) Fortified soy-based meat substitutes



Across:

6. Found in enriched, fortified, or whole-grain products
9. Found in the liver and in smaller amounts in fruits and meats
10. Found in unpolished grains, nuts, meats, and starches
11. Found in certain sea foods, red meats, and fortified cereals

Down:

1. Found in meat, fish, poultry, and fortified cereals
2. Found in some cereals, meats, poultry, fish, and beer
3. Found in organ meats, milk, bread products, and fortified cereals
4. Found in organ meats, seafood, and some plants
5. Found in milk, cheese, and yogurt
7. Found in nonheme sources such as grain products, fruits, and vegetables
8. Found in eggs, peas, meat, and cheese

Exercise 2: Water-Soluble Vitamins

Thiamin is a ________ that was once called vitamin _________.

There are two forms of thiamin in the body: free and phosphorylated. What are the three phosphorylated forms, where are they found, and what do they do?

1.

2.

3.

Briefly summarize the effects of thiamin supplementation in animal research models.

Repeated bouts of eccentric-based exercise result in a ________ in blood thiamin levels; however, thiamin depletion _____ alter aerobic performance.

What are the effects of thiamin supplementation on highly trained cyclists, leg muscle strength, and lactate levels?

Overall, based on the research presented, what can be said of thiamin supplementation?

Riboflavin is a B-complex vitamin, which is also known as _________.

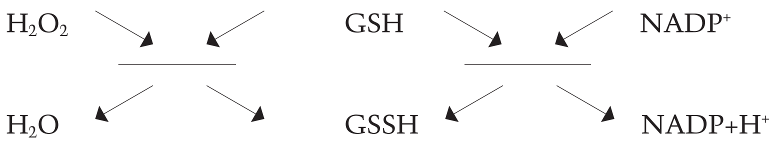
Riboflavin is a main component of what two coenzymes?

1.

2.

Which coenzyme has an important antioxidant role?

Fill in the following steps associated with the glutathione oxidation-reduction cycle:



What does the glutathione reductase do? What does it produce? How does this product compare with other antioxidant compounds in the plasma?

What does the current research suggest about riboflavin supplementation and performance?

Niacin is also known as vitamin____________.

What are the four forms of niacin utilized in the body?

1.

2.

3.

4.

Based on the current research, what be concluded about the effectiveness of niacin supplementation?

Pantothenic acid is also known as __________.

Pantothenic acid has a role as a component of coenzyme A. What four things does CoA have a role in?

1.

2.

3.

4.

Based on the current scientific research, what can be concluded about pantothenic acid supplementation effects on performance?

What are the six forms of vitamin B6 that can be found in the body?

1.

2.

3.

4.

5.

6.

What is the most studied form of vitamin B6? Why?

Summarize the current literature regarding vitamin B6 supplementation and performance.

Folate is also known as _____________.

What is the primary function of folate? Why is this important?

Does folate supplementation improve performance?

Biotin is also known as ____________.

Can biotin be synthesized in the body?

What are the four different enzymes that biotin can attach to?

1.

2.

3.

4.

Vitamin B12 contains __________ and thus is called a _____________.

Explain why vitamin B12 is important.

What are the two things from which B12 is constituted? What are they involved in?

1. ________________________:

2. ________________________:

What does the current body of scientific research suggest about vitamin B12 supplementation?

Vitamin C is also known as ______________.

Can vitamin C be synthesized in the body?

What are the three major functions of Vitamin C?

1.

2.

3.

Summarize the current body of scientific knowledge about vitamin C supplementation. Discuss vitamin C's antioxidant properties and its effect on DOMS.

What is a potential effect of taking a high dosage of vitamin C (above the RDA)?

Exercise 3: Fat-Soluble Vitamins

What two groups of antioxidants does the vitamin E group refer to? What forms do these come in?

1. ________________:

2. ________________:

Vitamin E has powerful antioxidant properties that:

1.

2.

Summarize the effects of vitamin E supplementation on muscle damage:

What is the current belief about whether or not vitamin E supplementation affects athletic performance?

What are the three retinoids encompassed by vitamin A?

1.

2.

3.

Which of the retinoids can be produced from beta-carotene and other carotenoids?

How do carotenoids work as antioxidants?

Does vitamin A supplementation affect performance?

The primary form of vitamin D utilized in the body is ________________.

What precursor of vitamin D3 can cholesterol be converted to?

What does ultraviolet light convert into vitamin D3?

Is there a need for vitamin D supplementation? Do deficiencies exist?

What are the two naturally occurring forms of vitamin K? What makes them?

1. _____________________:
2. _____________________:

What is the only role of vitamin K in the body?

Exercise 4: Minerals

What is the most abundant mineral in the body?

What happens if the diet is deficient in calcium?

Is calcium supplementation warranted? If not, are there any conditions for which it might be helpful?

Explain how calcium assists with muscle contraction. Where is it store? Where is it released from?

Chromium is essential to the diet, and there are two common forms. What are they? How are they noted in the literature?

1. ______________ (______________)
2. ______________ (______________)

What are the major functions of chromium in the body?

What were the results of the early studies on chromium supplementation?

Since the early work by Evans et al., many studies have been completed to replicate their work. What does the body of knowledge suggest about the ergogenic capabilities of chromium?

Iron is a major component of the heme groups in _________, _________, and __________.

What are the functions of cytochromes?

What is anemia and what are the consequences of this blood disorder?

What are the effects of low iron levels?

1.
2.
3.

Why are female athletes more prone to iron deficiencies and negative iron balances?

What does the recent literature suggest about iron supplementation and exercise performance?

Zinc has a role in several aspects of cellular function. What are these roles?

1.

2.

3.

What cytosolic antioxidant does zinc provide an important structure for?

What three cell-signaling properties does zinc exhibit?

1.

2.

3.

What does the scientific literature suggest about zinc supplementation?

The combination of zinc and magnesium-aspartate (ZMA) has received considerable attention in the scientific literature. Briefly summarize the effects of this supplement.

What has been reported in the literature about the effects of ZMA on:

1. IGF-1:
2. Total testosterone:
3. Free testosterone:
4. Cortisol:
5. Growth hormone:
6. Creatine kinase:
7. Bun/creatine ratio:
8. Liver enzyme efflux:
9. 1 RM strength:
10. Muscular endurance:
11. Muscular power:

Phosphorus is in the body in the form of __________, which is abbreviated as _______. What percentage of bone does this account for? ______

What major energy component does phosphorus have a major role in?

Selenium-dependent enzymes are termed _______ and are important for _____________________________________.

What has the current body of scientific literature concluded about the effectiveness of selenium supplementation?

Fill in the information in the following table:

Nutrient	**Dosage**	**RDA/AI—Men**	**RDA/AI—Women**	**UL**
Thiamin		1.2		ND
Riboflavin				
Niacin	mg/d		1.1	
Pantothenic acid				
Vitamin B6				
Folate				
Biotin				
Vitamin B12				
Vitamin C				
Vitamin E	mg/d			1000
Vitamin A				
Vitamin D				
Vitamin K				
Calcium				
Chromium				
Iron	mg/d		18	
Magnesium				
Zinc				
Phosphorus				
Selenium				
UL = tolerable upper limits, ND = not determined.				

Review Test

1. All of the following are considered macronutrients except:
   a. Carbohydrates
   b. Fats
   c. Proteins
   d. Vitamins

2. Fat-soluble vitamins are found in the fluid portion of the body and can accumulate in large amounts.
   a. True
   b. False

3. Zinc is found in:
   a. Red meats
   b. Milk
   c. Cheese
   d. Yogurt

4. Chromium is found in:
   a. Green vegetables
   b. Beer
   c. Poultry
   d. a and b
   e. b and c

5. Thiamin is also known as:
   a. B6
   b. B12
   c. B1
   d. B5

6. The effect of thiamin depletion on aerobic exercise performance:
   a. Increase
   b. Decrease
   c. No effect

7. Riboflavin is a primary component of which coenzymes?
   a. Flavin adenine dinucleotide
   b. Glutathione
   c. Flavin mononucleotide
   d. All of the above
   e. a and b
   f. a and c

8. What is the effect of riboflavin supplementation on aerobic performance?
   a. Increase
   b. Decrease
   c. No effect

9. Niacin is also known as:
   a. B1
   b. B3
   c. B6
   d. B12

10. All of the following are effects of niacin supplementation except:
   a. Increase 10-mile run time
   b. Attenuation of free fatty acids
   c. Increase in carbohydrate oxidation
   d. No change in 3.5 cycle time

11. Pantothenic acid has a large role in human metabolism by being a component of:
   a. Nicotinamide
   b. Pyridoxal
   c. Coenzyme A
   d. Nicotinamide adenine dinucleotide

12. Which of the following are forms of vitamin B6 found in the body?
   a. Pyridoxine
   b. Pyridoxal
   c. Coenzyme A
   d. a and b
   e. b and c

13. All of the following are improvements associated with vitamin B6 supplementation except:
   a. Decreased use of fatty acids
   b. Decreased use of muscle glycogen
   c. No improvements in aerobic performance
   d. No improvements in muscular strength

14. Folate is also known as folic acid.
   a. True
   b. False

15. What is the RDA for an adequate intake of folate for a young woman?
    a. 30 μg/d
    b. 700 μg/d
    c. 400 μg/d
    d. 55 μg/d

16. All of the following are water-soluble vitamins except:
    a. Vitamin A
    b. Vitamin C
    c. Vitamin D
    d. Vitamin K

17. Which of the following effects are related to vitamin C?
    a. Synthesis of collagen
    b. Improvements in aerobic performance
    c. Scavenging cytotoxic free radicals
    d. a and b
    e. a and c

18. Low iron levels affect all of the following except:
    a. The functionality of the electron transport chain
    b. The synthesis of neurotransmitters
    c. The synthesis of proteins
    d. The synthesis of fat

19. There are about 25 grams of magnesium in the body. What percentage is found in the muscle?
    a. 60%
    b. 27%
    c. 10%
    d. 5%

20. Zinc is an important component of cell signaling and might be related to apoptosis.
    a. True
    b. False

Review of Terminology

Introduction	Nicotinamide	**Minerals**
Antioxidant	Nicotinamide Adenine Dinucleotide Phosphate	Anemia
Fat-Soluble Vitamins	Nicotinamide Adenine Dinucleotide	Apoptosis
Free Radical	Nicotinic Acid	Calcium
Macronutrients	Oxidation	Catalase
Micronutrients	Pantothenic Acid	Chromium
Minerals	Pyridoxal	Cytochromes
Reactive Oxygen Species	Pyridoxal 5′-phosphate	Heme
Vitamins	Pyridoxine	Hemoglobin
Water-Soluble Vitamins	Pyridoxine 5′-phosphate	Iron
	Pyridoxamine	Magnesium
Fat-Soluble Vitamins	Pyridoxamine 5′-phosphate	Myoglobin
Alpha-Tocopherol	Riboflavin	Peroxidase Enzyme
Gamma Carboxyglutamic Acid	Succinyl-CoA	Phosphorus
Menaquinone-n	Thiamin	Phosphate
Phylloquinone	Thiamin monophosphate	Selenium
Retinoids	Thiamin pyrophosphate	Selenoproteins
Tocotrienols	Uric Acid	Superoxide
Vitamin A	Vitamin B12	Zinc
Vitamin D Cholecalciferol	Vitamin B6	Zinc Magnesium-Aspartate
Vitamin E	Vitamin C	
Water-Soluble Vitamins	Xanthine	
Acetyl-CoA	Xanthine Oxidase	
Acetyl-coenzyme		
Ascorbic Acid		
B-complex vitamin		
Biotin		
Coenzyme A		

Delayed Muscle Soreness		
Essential Fats		
Flavin adenine dinucleotide		
Flavin mononucleotide		
Flavins		
Folate		
Folic Acid		
Glutathione		
Glutathione Peroxidase		
Glutathione Reductase		
Methylcobalamin		
Methylcrotonyl-CoA		
Niacin		

Important Abbreviations

ATP	GSSH
B1	H_2O_2
B12	MDA
B2	MgATP
B3	NAC
B5	$NADP^+$
B6	$O2\cdot^-$
ChrPic	OH^-
CoA	$OH\cdot$
CuZnSOD	PL
DEXA	PLP
DOMS	RDA
FAD	TPP
$Fe2^+$	TTP
GSH	ZMA

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Nutritional Needs of Endurance Athletes

Objectives

On the completion of this chapter, you will be able to:

1. Discuss the fluid needs and rehydration strategies that are used with endurance athletes.
2. Understand the physiologic ramifications of dehydration and hyponatremia.
3. Explain the macronutrient and micronutrient needs of endurance athletes.
4. Describe the effects of nutrient timing on recovery and performance in endurance athletes.
5. Discuss the ramifications of electrolyte imbalances and how consuming electrolytes can affect recovery and performance.
6. Understand the potential micronutrient needs of endurance athletes and potential food sources that might act as a countermeasure to deficiencies.
7. Outline the proper methods for carbohydrate-loading and explain which athletes this might best benefit.
8. Discuss the pitfalls that can occur when an endurance athlete undertakes a vegetarian dietary regime.
9. Explain the ramifications of a disordered eating pattern coupled with excessive exercise training in endurance athletes.
10. Discuss the three components of the female athlete triad.
11. Outline the warning signs that suggest an athlete is at risk for disordered eating behaviors.
12. Understand the possible factors that might contribute to gastrointestinal distress in endurance athletes.

Learning Exercises

Exercise 1: Fluid Needs of The Endurance Athlete

What are the primary causes of the increased risk of dehydration associated with endurance athletes, especially those who are training multiple times in a 24-hour period?

Proper hydration can ensure what?

1.

2.

3.

A 1%–2% loss in body weight as a result of dehydration can cause:

1.

2.

3.

4.

What are some ways that an endurance athlete can monitor their exercise-induced fluid losses?

How much water should an endurance athlete consume for every pound decrease in weight in response to the bout of exercise? What time frame is needed for this fluid consumption?

Why is mild dehydration (i.e. <_____% body weight loss) somewhat unavoidable during long-duration exercise bouts (>_____ hours)?

Explain how the capacity of the gastrointestinal tract can impact dehydration.

Why is it advisable for endurance athletes to practice hydration techniques during practice?

What are the general recommendations for hydration for endurance athletes?

1.

2.

3.

Exercise 2: Calorie and Macronutrient Needs

Why should endurance athletes vary their caloric intake throughout their training cycles?

What is the most important macronutrient that must be consumed to support the energy demands of the exercising endurance athlete?

How many grams of carbohydrate are necessary when:

1. Training 1 hour per day: ______________________
2. Training 2 hours per day: ______________________
3. Training 3–4 hours per day: ____________________
4. Training 4–6 hours per day: ____________________

If an endurance athlete is training with moderate-duration, low-intensity exercise, what would be an acceptable carbohydrate content for the diet? ___________ g

Is protein an important component of an endurance athlete's diet? Why?

What three amino acids have been shown to be broken down in response to long-duration exercise?

1.

2.

3.

What percentage of energy need during rest or exercise, in well-fed individuals, does protein supply?

At the end of a long or prolonged endurance exercise bout, what percentage of energy need does protein supply?

Fill in the following table regarding protein needs of endurance athletes:

	Protein recommendations
Elite endurance athletes	
Well-trained endurance athletes	
General recommendation for endurance athletes	

Why might a very low-fat diet not be recommended for an endurance athlete?

How do diets with 20%–25% of their calories from fat compare with diets with <15% of their calories from fat?

Low-fat diets have been associated with inadequate intake of what three key nutrients?

1.
2.
3.

Explain what occurs when an endurance athlete undertakes a fat-loading regime.

In a fat-loading diet, what percentage of daily calories comes from fat?

Is the process of fat loading a recommended dietary practice for endurance athletes?

Dietary fat intake should be approximately _________ g/kg per day for the endurance athlete.

Exercise 3: Macronutrient Timing

What are the three components of recovery?

1.

2.

3.

Explain the current preexercise recommendations for endurance athletes. How much carbohydrate, protein, and fat should they consume? How long before exercise should they eat? How long should the exercise bout be for this basic procedure?

If the bout of exercise is less than 90 minutes, does the procedure outlined above change?

Poor eating coupled with training over successive days will result in what?

Insufficient recovery that might occur from cumulative glycogen depletion (as a result of poor diet and repetitive training) can result in:

1.

2.

3.

Athletes who exercise with low glycogen stores can ________ their risk of injuries.

Complete replenishment of muscle glycogen can take ~________ hours.

What is the "carbohydrate window"? How long after exercise does it last?

What is the recommendation for carbohydrate consumption during the "carbohydrate window"?

Recent recommendations suggest that consuming small amounts of protein after exercise might be beneficial for the endurance athlete. Why?

During intense endurance exercise, it is recommended that athletes consume between ____ and ____ g of carbohydrate per hour or ~ ____ to ____ calories per hour.

Another recommendation is that endurance athletes should consume ____ g of carbohydrate per kilogram of body mass during each hour of exercise.

If the exercise bout is very long, what happens? Does the athlete have to increase their carbohydrate consumption rate?

Give three examples of carbohydrate sources that can make it easier for endurance athletes to meet their carbohydrate needs during exercise:

1.

2.

3.

What are some of the benefits of adding small amounts of protein during exercise?

1.

2.

3.

Exercise 4: Electrolyte Needs of The Endurance Athlete

What is hyponatremia? What causes it?

List the nine symptoms that can occur during or after an endurance bout that are indicative of hyponatremia?

1.
2.
3.
4.
5.
6.
7.
8.
9.

What types of athletes have an increased risk of experiencing hyponatremia? Is there a gender difference?

Explain the primary culprit for causing hyponatremia.

List three possible reasons for the occurrence of muscle cramping:

1.
2.
3.

A diet that is rich in ___________ and adequate __________ has the potential to prevent muscle cramping.

Fill in the following table regarding the signs and symptoms of dehydration or hyponatremia:

Dehydration		**Hyponatremia**	
Stage	Symptoms	Stage	Symptoms
Early:		Early:	
Advanced:		Advanced:	

Exercise 5: Micronutrient Needs of The Endurance Athlete

Why is iron an important micronutrient for endurance athletes?

List three categories of athletes that are at risk for anemia:

1.
2.
3.

What is the second biggest cause of low iron levels in women?

Iron loss from sweat is usually __________; however, during prolonged exercise, iron loss can be ______________.

Repetitive foot strikes as a result of hard running does what?

How should an athlete undertake an iron supplementation regime? What things need to be monitored?

Explain zinc's role.

List 12 dietary sources of zinc:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.

List three things that calcium is necessary for:

1.
2.
3.

Fill in the following table:

Age classification	Calcium recommendation
>50 years	
19–50 years	
9–18 years	

What are some good sources of calcium?

List four things that competitive athletes should do when planning and practicing rehydrating and fueling strategies:

1.
2.
3.
4.

Exercise 6: Carbohydrate Loading

What type of athletes should carbohydrate load?

Why should athletes consider carbohydrate loading?

Explain the best methods for carbohydrate loading. How much carbohydrate is needed?

Exercise 7: Vegetarian Diets and Endurance Athletes

Can a vegetarian diet be safe and applicable for an endurance athlete?

If an endurance athlete simply eliminates animal products from their diet, what are eight problems that can occur?

1.
2.
3.
4.
5.
6.
7.
8.

In some instances, the presence of a vegetarian diet can be a red flag, which can indicate what?

A semi-vegetarian who drinks milk or eats dairy products probably gets enough ____________, _____________, and ______________. However, they might be deficient in ___________ and _________ intake.

An athlete who is in "carbohydrate overload" might be at risk for being inadequate in what three dietary components?

1.

2.

3.

List the two plant sources that offer the highest-quality protein choices:

1.

2.

What sources should vegetarians use to account for their needs for the following nutrients? Why is this important?

1. Zinc:
2. Iron:
3. B12:

Exercise 8: Disordered Eating, Eating Disorders, and the Female Athlete Triad

Define the following disorders that endurance athletes could be susceptible to:

1. Anorexia nervosa:
2. Bulimia nervosa:

What is the myth that many endurance athletes believe in that causes them to be at risk for eating disorders?

Do people recover from eating disorders? How?

What are the three components of the female athlete triad?

1.

2.

3.

Who is at risk for having the female athlete triad?

Describe in detail what is meant by the "energy drain scenario"?

Explain the process that the body undergoes in order to respond to an inadequate amount of calorie intake.

When a woman is amenorrheic between the ages of 16–_______, she can lose as much as ______% of her bone mass each year.

What are some of the possible effects of the female athlete triad, depending on the number of years it is experienced?

1.
2.
3.
4.
5.
6.
7.
8.
9.

List seven potential red flags that should be observed in high-risk populations such as active female endurance athletes.

1.
2.
3.
4.
5.
6.
7.

Discuss several things that a female endurance athlete can do to address the occurrence of the female athlete triad.

Exercise 9: Gastrointestinal Issues

Give four examples of potential gastrointestinal disorders that can affect endurance athletes.

1.

2.

3.

4.

Increases in ________ that occur in response to intense physical activity or emotional stress can contribute to GI distress.

What are two things that happen to an athlete when they become dehydrated that might affect the GI tract.

1.

2.

Diarrhea and cramping seem to be a particular problem for __________ athletes.

Discuss potential countermeasures that an endurance athlete can undertake to avoid gastrointestinal disorders.

Exercise 10: Extreme Environmental Conditions, Training, and Competition

Why is heat the most extreme physiologic condition under which an endurance athlete can compete?

What type of foods should an endurance athlete consume when performing exercise in a hot environment?

Discuss how and why there is a potential for dehydration during endurance exercise in a cold environment.

What are some strategies for endurance athletes to effectively exercise in cold environments?

What are two things that can occur when exercising at altitude?

1.

2.

Discuss why iron supplementation might be useful to female endurance athletes who live and train at moderate altitudes.

Review Test

1. It is widely accepted that a high-fat diet is the preferred diet when preparing to exercise in a cold environment.
   a. True
   b. False

2. When using iron supplementation, all of the following need to be monitored except:
   a. Hematocrit
   b. Ferritin
   c. Plasma volume
   d. Hemoglobin

3. Foods such as __________ should be avoided in the time period before exercising or competing because they tend to form gas and thus contribute to gastrointestinal distress.
   a. Glucose
   b. Cabbage
   c. Amino acids
   d. None of the above

4. Exercising in a hot environment is considered to be the most severe physiologic environment that an endurance athlete can encounter.
   a. True
   b. False

5. The increase in __________ associated with intense exercise can interfere with gastrointestinal functionality.
   a. Cortisol
   b. Insulin
   c. Vasopressin
   d. Epinephrine

6. All of the following are warning signs that indicate that a woman is at high risk for an eating disorder except:
   a. The athlete has exercise-induced amenorrhea
   b. The athlete is compulsive or nonpurposeful in her exercise habits
   c. The athlete exhibits strong coping skills
   d. The athlete is too busy or often forgets to eat

7. Women who have amenorrhea between the ages of 16–30 years can lose as much as _____ of their bone mass with each passing year.
   a. 2%–5%
   b. 5%–8%
   c. 8%–11%
   d. 11%–14%

8. All of the following are considered possible effects of a disordered eating pattern that places the female athlete in a continual negative energy balance except:
   a. The onset of puberty can be delayed
   b. The athlete will develop a normal body stature
   c. The athlete can experience a prevalence of lingering overuse injuries
   d. The athlete is more susceptible to stress fractures

9. Which of the following conditions are considered to be part of the female athlete triad?
   a. Osteoporosis
   b. Regular menstruation
   c. Disordered eating
   d. a and b
   e. a and c
   f. None of the above

10. When an athlete consistently intakes inadequate calories, the body attempts to spare energy use by stimulating the reproductive system via the hypothalamic-pituitary-ovarian axis.
    a. True
    b. False

11. An athlete who undergoes a cycle of binging on food followed by periods of purging would be classified as having:
    a. Anorexia nervosa
    b. Self-starvation
    c. Bulimia nervosa
    d. All of the above

12. Semi-vegetarians can often meet their dietary needs for _________ by eating just dairy foods and eggs.
    a. Vitamin B12
    b. Iron
    c. Protein
    d. Calcium

13. The vegetarian diet can be extremely unhealthy because it can be:
    a. High in saturated fat
    b. High in refined sugar
    c. Deficient in calcium content
    d. All of the above

14. A well-planned diet can meet all the macronutrient and micronutrient needs of an endurance athlete.
    a. True
    b. False

15. Scientific inquiry has demonstrated that carbohydrate loading can increase muscle glycogen stores by as much as _______%.
    a. 100–200
    b. 200–300
    c. 50–100
    d. 300–400

16. Which of the following can enhance glycogen stores and would be an example of glycogen loading?
    a. Consuming a high-carbohydrate diet (~7–10 g/kg body mass) while exercising at a low intensity for 3 days
    b. Consuming a high-carbohydrate diet (~7–10 g/kg body mass) while exercising at a high intensity for 3 days
    c. Consuming a low-carbohydrate diet (~3–4 g/kg body mass) while exercising at a high intensity for 8 days
    d. Consuming a low-carbohydrate diet (~3–4 g/kg body mass) while exercising at a low intensity for 8 days

17. All of the following athletes are prime candidates for carbohydrate loading except:
    a. Ultramarathon runners
    b. Triathletes
    c. 5-km runners
    d. Marathon runner

18. Which food choices would be sources of iron?
    a. Lentils
    b. Oysters
    c. Baked potatoes
    d. Chick peas

19. A 30-year-old man would need _______ mg of calcium a day.
    a. 1300
    b. 1200
    c. 1100
    d. 1000

20. All of the following are signs of advanced hyponatremia except:
    a. Abnormal chills
    b. Respiratory distress
    c. Confusion or disorientation
    d. Seizures

Review of Terminology

Fluid Needs	**Macronutrient Timing**	**Electrolyte Needs**
Dehydration	Carbohydrate	Electrolytes
	Carbohydrate Window	Hyponatremia
Calorie and Macronutrient Needs	Muscle Soreness	Muscle Cramping
Amino Acids	Recovery	Overexertion
Branched-Chain Amino Acids		
Calcium	Micronutrient Needs	Carbohydrate Loading
Carbohydrate	Anemia	Carbohydrate Loading
Essential Fatty Acids	Calcium	Glycogen Depletion
Fat	Hematocrit	Hypoglycemia
Fat-Loading	Hemoglobin	
Isoleucine	Iron	Disordered Eating
Leucine	Serum Ferritin	Amenorrhea
Protein	Zinc	Anorexia Nervosa
Valine		Bulimia Nervosa
Zinc	Gastrointestinal Disorders	Female Athlete Triad
	Abdominal Cramps	Menstrual Cycle
Extreme Environments	Diarrhea	Osteoporosis
Cold-Induced Diuresis	Nausea	
Heat Acclimatization	Vomiting	

Important Abbreviations

AMS	GI

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Nutritional Needs of Strength/ Power Athletes

Objectives

On the completion of this chapter, you will be able to:

1. Discuss the different components of the basal metabolic rate.
2. Calculate an individual's basal metabolic rate and account for physical activity.
3. Explain the different methods for determining basal metabolic or resting metabolic rate.
4. Determine the amount of calories needed to add to a diet to gain weight or determine the amount of calories needed to lose weight.
5. Discuss the macronutrient ratios needed by strength/power athletes.
6. Address the issues associated with protein needs of strength/power athletes.
7. Understand the different types of protein supplements and dietary protein that can be used in a healthy diet.
8. Explain the importance of fat in the diet and delineate between the different types.
9. Describe why carbohydrates are important to the strength/power athlete.
10. Address the carbohydrate needs of different types of strength/power athletes.
11. Discuss the different vitamins and minerals that might be needed by strength/power athletes.
12. Understand the ramifications of poor hydration and describe how to rehydrate athletes.
13. Comprehend that water is essential for optimal performance and understand that fluids can be gained from food sources.

Learning Exercises

Exercise 1: Energy Requirements of Strength/Power Athletes

Define the following terms:

1. Basal metabolic rate (BMR):
2. Resting metabolic rate (RMR):
3. Thermic effect of food:

What four things are primary determinants of the BMR?

1.
2.
3.
4.

The BMR does not account for: ______________

Which component of daily energy requirements is most variable?

Explain how one can calculate an individual's BMR with indirect calorimetry.

What three things must be controlled in order to get a true BMR?

1.
2.
3.

Compare and contrast the BMR and the RMR.

List and describe the three factors that are accounted for in the Harris-Benedict equation.

1.
2.
3.

1 kg = _______ pounds

1 cm = _______ inches

Based on the data presented below, use the Harris-Benedict equation to calculate BMR (make sure you show your work):

Male:	212 pounds 5 ft. 10 in. 36 years	Female:	147 pounds 5 ft. 5 in. 37 years
BMR=		BMR=	

Based on the data presented below, use the Food and Agriculture Organization system to calculate BMR (make sure you show your work):

Male	15 years 175 pounds	Female:	20 years 132 pounds
RMR=		RMR=	
Male:	75 years 165 pounds	Female:	45 years 178 pounds
RMR=		RMR=	

Compare and contrast the Harris-Benedict equation with the FAO/WHO/UNU equations.

Exercise 2: Physical Activity Factors

Explain what the daily physical activity level factor is.

Fill in the following table:

Activity factor	**Review Test**
	Sedentary or light activity
	Active or moderate activity
	Vigorous activity

Using the data provided below calculate the BMR and total minimal calorie requirement for the individual presented (make sure you show your work).

Male:	Height = 6 ft. 4 in. Weight = 390 pounds Activity = trains three times a day (2 hours per session); weightlifting
RMR =	
Minimal daily calorie requirements =	

If an athlete wants to maintain their body weight, calorie intake ____ __________ the minimal daily calorie requirements.

If an athlete wants to lose 1 pound a week:

1 pound of fat = __________ calories.

Calorie intake ___________ than the minimal daily calorie requirements.

If an athlete wants to gain 1 pound of muscle:

1 pound of muscle = __________ calories.

To gain 1 pound a week, an athlete needs to consume __________ calories more than their daily energy requirements.

Exercise 3: Macronutrient Needs

As a general rule, what percentage of the diet consists of:

1. Carbohydrate: _______________
2. Protein: _______________
3. Fat: _______________
4. Saturated fat: _______________

Explain what is meant by the ratio rule?

Which types of anaerobic sports require more carbohydrates and which require less?

Exercise 4: Protein Intake for Strength/Power Athletes

Proteins are formed from combinations of ________________.

Protein serves as a major structural component of:

1.

2.

To increase muscle size, what is required?

After acute bouts of resistance training, ___________ is increased in humans and surpasses the ______ rate for up to 48 hours after training.

Hyperaminoacidemia and increased protein intake result in increased __________.

It has been shown that protein balance remains _____________ after training if athletes consume too little protein.

The recommendation for protein intake in the general population is _________ g/kg/day, whereas strength/power athletes probably need _________ g/kg/day.

Fill in the following table based on the supplied information:

Female	Weight = 120 pounds	Male	Weight = 320 pounds
Protein need = g/day		Protein need = g/day	

How do protein sources differ?

List and describe the various methods for determining the quality of proteins:

1. _________________:

2. _________________:

3. _________________:

4. _________________:

In the following table, fill in all the appropriate information:

Terminology	Example food sources
Complete protein:	1. 2. 3. 4.
Incomplete protein:	1. 2. 3. 4.

Why might protein supplements be a useful tool for athletes?

What are considered to be the four best sources for high-quality protein supplements?

1. ______________
2. ______________
3. ______________
4. ______________

The highest-quality protein supplements contain:

1. ____
2. ____

Give an example and discuss the following:

1. Slow protein:
2. Fast protein:

Does the use of slow or fast protein supplements after exercise result in different effects on protein synthesis?

Compare and contrast the effects of soy and milk protein sources.

Exercise 5: Carbohydrate Intake for Strength/Power Athletes

Carbohydrate is stored in the _________ and ___________ as glycogen.

Is glycogen an important substrate during resistance training? Can it affect performance when it is depleted?

Most research suggests that resistance training can reduce muscle glycogen by ____________%, depending on the intensity and duration of the training bout.

Which fiber types seem to be most susceptible to muscle glycogen loss?

Which types of resistance training programs seem to have the greatest effects on muscle glycogen?

Most strength/power athletes require ________ of their total caloric intake to come from carbohydrates. This intake supplies approximately _______ grams of carbohydrates per kilogram body mass.

What is meant by the glycemic index?

Fill in the following table of examples of high and low glycemic index foods:

High glycemic foods	**Low glycemic foods**
1.	1.
2.	2.
3.	3.

Compare and contrast the carbohydrate recommendations for pre- and postexercise dietary practices. Make sure to relate this to the glycemic index.

What are some of the effects of consuming 1 g of glucose per kilogram body mass immediately and 1 hour after a resistance training bout?

1.

2.

3.

4.

5.

6.

Why might a postexercise insulin spike be beneficial for a strength/power athlete?

1.

2.

Why might it be useful to combine protein and carbohydrate in a post–resistance-training supplement?

Exercise 6: Fat Intake for Strength/Power Athletes

Explain why it might be useful for the strength/power to consume higher amounts of fat.

What are the two things that fat can aid in?

1.

2.

The digestion and absorption ability of these four fat-soluble nutrients can be affected by dietary fat intake:

1.

2.

3.

4.

List three examples of carotenoids that can be found in fruits and vegetables.

1.

2.

3.

The general recommendation for fat intake of strength/power athletes is _______, with only _______ or fewer coming from saturated fats.

Explain the difference in circulating testosterone levels in relation to high- and low-fat diets.

Why might it be important to maintain circulating testosterone levels?

What does the scientific literature suggest about the importance of cholesterol in attempting to stimulate muscle growth and improve overall muscular strength?

The vast majority of fat intake of strength/power athletes should come from___________ (_____%) and ___________ (______%).

What type of dietary fats lowers blood cholesterol and triglycerides while stimulating an increase in high-density lipoproteins?

Why should strength/power athletes avoid trans fats?

Exercise 7: Vitamins and Minerals for Strength/Power Athletes

Fill in the following table with examples of fat- and water-soluble vitamins:

Fat-soluble vitamins	**Water-soluble vitamins**
1.	1.
2.	2.
3.	3.
4.	4.

What are antioxidants, and what are some example vitamins that have antioxidant properties?

Give examples of minerals that also exhibit antioxidant properties.

Discuss the current literature on vitamin E supplementation and resistance training.

Why do the B vitamins need to be consumed on a daily basis? Do deficiencies in B vitamins affect athletic performance?

Is the mineral chromium a useful supplement for the strength/power athlete?

What is the role of calcium in the body, and how is calcium intake in the diet linked to fat loss?

Discuss the potential effects of zinc magnesium-aspartate (ZMA) supplementation.

What is a very simple general recommendation regarding vitamins and minerals that can be made to strength/power athletes?

Exercise 8: Hydration and Strength

The body is only ______% efficient at turning fuel energy into useable energy. That leaves ____% of the fuel energy to be lost as heat.

As a general rule, ____% body weight loss from dehydration or water loss can result in performance impairments.

Recent research has linked as little as ______% loss of body weight to performance decrements.

Why are body weight losses of more than 4% not recommended?

Are athletes who work out two times a day at more risk for heat-related illnesses? What is an important countermeasure for this possibility?

A typical sweat rate for an athlete is approximately ________ L per hour depending on several factors, such as training status, environmental stressors, body size, and acclimatization status.

In detail, give an example hydration strategy that an athlete can use to achieve optimal performance.

Fill in the table below:

	Fluid-replacement requirement		
Weight loss	**Ounces**	**Liters**	**Milliliters per minute**
4 pounds			
6–8 pounds			

Would it be possible for an athlete to consume 15 mL per minute? What might be an alternative method of rehydration?

If a strength/power training session lasts more than 90 minutes, what should the athlete consume?

Explain why thirst is not a good indicator of when to hydrate.

When training in a hot environment, the general rule is to consume _______ ounces (______ mL) of fluid for every pound of body weight lost.

Overall, it has often been recommended that the consumption of eight 8-oz. glasses of water a day is needed to stay hydrated. However, recent research suggests this is not enough. Fill in the following table based on the latest research.

Gender	Fluid requirements
Men	
Women	

Fill in the table below with the appropriate fluid-loss measures:

Fluid-loss site	Amount lost (mL/day)
Kidneys (urine loss)	
Skin (sweat loss)	
Lungs (moisture loss)	
Gastrointestinal tract	

If an individual consumes too much plain water, what might they be at risk for?

Fill in the following table concerning fluid content of foods:

Food source		
Food	**Serving size**	**Fluid content**
Cucumber	1 large	
Baked potato	1 medium	
Brown rice	1 cup	
Kidney beans	1 cup	
Watermelon	1 wedge	
Grapes	1 cup	
Baked beans	1 cup	
Oatmeal	1 cup	
Orange	1 medium	
Salad	1.5 cups	

The ACSM recommends _______________mL of fluid intake for men and ______________mL of fluid intake for women.

Explain some of the methods that can be used to ensure that athletes remain properly hydrated.

Review Test

1. The greatest loss of fluid during a normal day comes from:
   a. Moisture loss while breathing
   b. The kidneys via the formation of urine
   c. The skin via sweating
   d. From the gastrointestinal tract

2. If a 200-pound football player were to lose 4 pounds, he would need to consume:
   a. 1.8 L of fluid to rehydrate
   b. 15 mL of fluid every minute for 2 hours to rehydrate
   c. 3.6 L of fluid to rehydrate
   d. a and b
   e. b and c

3. Depending on environmental factors, training status, and anthropometrics, a typical athlete can lose between ________ L of fluid per hour via sweat.
   a. 0.5–2.0
   b. 1.8–3.2
   c. 2.2–3.4
   d. 0–0.5

4. The effect of losing 1.5% of body weight via fluid loss on muscular strength:
   a. Increase
   b. Decrease
   c. No effect

5. The body generally is only 60% efficient at turning fuel energy into usable energy.
   a. True
   b. False

6. Fat is essential for digestion and absorption of all of the following except:
   a. Lycopene
   b. Zeaxanthin
   c. Vitamin D
   d. Vitamin C

7. The consumption of carbohydrates immediately and 1 hour post–resistance training:
   a. Increases myofibrillar protein breakdown
   b. Increases urea nitrogen excretion
   c. Increases plasma glucose and insulin levels
   d. Decreases fractional muscle protein synthesis

8. After exercise, it is advisable to consume high glycemic index carbohydrates, such as:
   a. Sports drinks
   b. Oatmeal
   c. Lentils
   d. Whole-grain breads

9. The effect of acute resistance-training bouts of exercise on muscle glycogen stores:
   a. Increase
   b. Decrease
   c. No effect

10. It is recommended that strength/power athletes consume between 55%–60% of their calories from carbohydrates.
    a. True
    b. False

11. Protein quality can be determined by:
    a. The protein-efficiency ratio
    b. The biologic value of protein
    c. The net protein utilization
    d. All of the above

12. Dietary supplements that contain ____________ are often considered the best because of their high bioavailability and complement of critical amino acids.
    a. Whey protein
    b. Soy protein
    c. Whey protein isolates
    d. a and b
    e. a and c
    f. b and c

13. Strength/power athletes require between ____________ grams of protein per kilogram body mass per day.
    a. 0.8–1.2
    b. 1.5–2.0
    c. 1.8–2.2
    d. 2.0–2.5

14. When comparing milk and soy protein sources combined with 12 weeks of resistance training, all of the following occur except:
    a. Greater hypertrophy when consuming soy protein
    b. Greater increases in amino acid uptake with milk protein use
    c. Greater protein deposition in skeletal muscle with milk protein use
    d. Greater gain in protein synthesis with milk protein use

15. It is recommended that strength/power athletes only eat three large meals a day.
    a. True
    b. False

16. If Janna weighs 60 kg, is 163 cm tall, and bicycles 50 miles a day, her minimal daily calorie need might be estimated as ____________calories.
    a. 1399
    b. 2140
    c. 2462
    d. 3147

17. When examining the total caloric need of an individual, the smallest component is the:
    a. Thermic effect of food
    b. Basal metabolic rate
    c. Resting metabolic rate
    d. Caloric expenditure from physical activity

18. The basal metabolic rate is composed of:
    a. The thermic effect of food
    b. The energy expenditure from physical activity
    c. The caloric expenditure of the body's organs, tissues, and physiologic systems
    d. a and b
    e. b and c

19. Women tend to have a metabolic rate that is 5%–10% higher than that of men.
    a. True
    b. False

20. When calculating total caloric need, the PAL factor for an active or moderately active individual is:
    a. 1.76
    b. 2.25
    c. 1.53
    d. 3.25

Review of Terminology

Energy Requirements	**PAL Factors**	**Macronutrient Needs**
Basal Metabolic Rate	Calories	Carbohydrate
Indirect Calorimetry	Physical Activity Level	Fat
Resting Metabolic Rate	Weight Gain	Macronutrient
Thermic Effect of Food	Weight Loss	Protein
	Weight Maintenance	Ratio Rule
Protein Intake		Saturated Fat
Amino Acids	Carbohydrate Intake	
Biologic Value	Glycemic Index	**Fat Intake**
Casein	High Glycemic Carbohydrates	Carotenoids
Complete Protein	Insulin	Cholesterol
Essential Amino Acids	Liver Glycogen	C-Reactive Protein
Glutamine	Low Glycemic Carbohydrates	Fatty Acids
Incomplete Protein	Muscle Glycogen	High-Density Lipoprotein
Isoleucine	Type II Muscle Fibers	Intramuscular Triglyceride
Leucine		Low-Density Lipoprotein
Net Protein Utilization	**Vitamins and Minerals**	Lutein
Protein Degradation	β-Carotene	Lycopene
Protein Digestibility	Calcium	Monounsaturated Fat
Protein Synthesis	Fat-Soluble Vitamins	Polyunsaturated Fat
Protein-Efficiency Ratio	Iron	Saturated Fat
Valine	Magnesium	Testosterone
Whey Protein	Niacin	Trans Fat
	Riboflavin	Triglycerides
Hydration	Thiamin	Vitamin A
Dehydration	Water-Soluble Vitamins	Vitamin D
Hyponatremia	Zinc	Vitamin E
	Zinc Magnesium-Aspartate	Vitamin K
		Zeaxanthin

Important Abbreviations

ATP	PAL
BMR	RMR
FAO	UNU
GI	WHO
HDL	ZMA
LDL	

18
A Different Look at the Food Guide Pyramid

Objectives

On the completion of this chapter, you will be able to:

1. Understand the evolution of dietary recommendations.
2. Differentiate between the traditional Food Guide Pyramid and the My Pyramid recommendations.
3. Explain in detail the different components that make up the My Pyramid recommendations.
4. Discuss how the My Pyramid recommendations can be adjusted to address the nutritional needs of athletes.
5. Understand some of the limitations of the My Pyramid recommendations.
6. Describe how the My Pyramid recommendations can be modified to better depict the appropriate dietary recommendations.
7. Discuss how lobbyists, such as the Beef Cattle Lobby, have potentially influenced the recommendations.
8. Give examples of how an individual can meet the My Pyramid recommendations.

Learning Exercises

Exercise 1: History of the USDA Food Guide Pyramid

The 1946 National Food Guide contained seven categories. What were they?

1.
2.
3.
4.
5.
6.
7.

Explain what the main focus was for the 1946 food guide?

The 1956 Food Guide Pyramid contained only four food groups. What were they?

1.
2.
3.
4.

In the 1979 "Hassle-Free Guide to a Better Diet" was a modification to "The Basic Four" food guide presented in 1956. What was this modification?

In 1992, the first major change was made to the food guide and the "Food Guide Pyramid" was created. Based on the format of the pyramid, what was the major tenet behind the recommendations?

Discuss some of the problems that have been associated with the Food Guide Pyramid.

Fill in the following table based on the 1992 Food Guide Pyramid:

Food grouping	Recommendations
Breads, Cereal, Rice, and Pasta Group	
Fruit Group	
Vegetable Group	
Milk, Yogurt, and Cheese Group	
Meat, Poultry, Fish, Dry Beans, Eggs, and Nut Group	
Fats, Oils, and Sweets	

Exercise 2: 2005 USDA My Pyramid

The My Pyramid makes recommendations into four broad categories:

1.

2.

3.

4.

Discuss the concept of variety in the diet as it relates to the 1992 Food Guide Pyramid.

What is the fundamental change made with the My Pyramid concerning variety?

What does a narrowing of a bar represent?

The My Pyramid has six different colors going from top to bottom and only varying in width. What do the six bars represent?

1.

2.

3.

4.

5.

6.

Foods at the top of the pyramid are____________, ______________, and are higher amounts of _______ and _______. Because the top of the pyramid has narrower bands, this suggests _________ of these food should be eaten.

The bottom of the pyramid depicts wider bands and suggests that these foods are ______________, __________________, and should be a larger portion of the diet.

One of the major additions to the My Pyramid is the addition of steps going up one side of the pyramid. What does this represent? Why is this important to relate to diet?

What does the My Pyramid slogan of "Steps to a Healthier You" indicate?

The grain group is the widest section of the pyramid and is depicted in an ________ color.

What type of grains is suggested to be the foundation of this group?

List examples of food choices that fall into the food group category.

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.

Americans typically consume which type of grains most frequently? What are some ramifications of consuming foods of this type?

What are three ways to make half of your grains whole?

1.

2.

3.

When examining the vegetable group in the My Pyramid, what is different from the 1992 Food Guide Pyramid?

What types of vegetables are emphasized in the My Pyramid?

Lit three examples of how one might vary their vegetables:

1.

2.

3.

The Milk Group is the greatest source of ___________ in the diet.

The My Pyramid emphasizes ___________ or _________ choices.

What is the recommendation for those who are lactose intolerant?

What are the three most frequently consumed dairy products?

1.

2.

3.

List three guidelines for ensuring adequate calcium-rich foods are in the diet:

1.

2.

3.

The Fruit Group places an emphasis on consuming ____________ and deemphasizes the consumption of _____________.

What are three guidelines that can assist in meeting the My Pyramid guidelines for fruit consumption?

1.

2.

3.

What are the five major recommendations in the Meat and Bean Group of the My Pyramid guidelines?

1.

2.

3.

4.

5.

List the three recommended methods for preparing meats:

1.

2.

3.

Why is it important to choose lean cuts of meat?

List three guidelines for choosing appropriate protein sources.

1.

2.

3.

The oils recommended in the My Pyramid guidelines are _______ at room temperature.

The unhealthy saturated fats are often ________ at room temperature.

Explain why trans fats should be avoided.

How are discretionary calories represented?

Most people have between _______ and ______ discretionary calories per day.

What part of the My Pyramid is designed to emphasize the importance of physical activity?

How many minutes of physical activity are recommended per day?

Exercise 3: Adjustments to the My Pyramid for Athletes

The My Pyramid recommendations are designed for ____________.

The My Pyramid does not take into account rigorous training, thus what needs to be done with its recommendations?

What adjustments must be made to the recommendations in the Carbohydrate Group when working with athletes?

Why is it necessary for athletes to consume large amounts of fruits and vegetables?

Discuss why the Beans and Nuts Group can be very important to the athlete.

Why are lean protein sources important for athletes to focus on when addressing the Meat Group recommendations?

The human body is made up of approximately ________ water.

Dehydration that causes as little as a ______ reduction in body mass can result in a _____ decrease in endurance performance.

Exercise 4: Problems with My Pyramid

What about the shape of the My Pyramid makes it confusing to the general population compared with previous recommendations?

Discuss one of the major problems concerning the colors and what food groups they represent on the My Pyramid.

Why might it be a problem that there are no serving-size recommendations on the My Pyramid?

Discuss one possible recommendation to deal with the lack of serving-size recommendations on the My Pyramid.

The lack of information on a recommended level of physical activity on the My Pyramid presents a problem. Why?

Why might it be important for the pyramid to have some recommendations about body weight?

What are three example diseases that are related to being overweight?

1.

2.

3.

Explain why the modifications to the original Food Guide Pyramids, which resulted in the My Pyramid, could actually make it more difficult for individuals to understand the importance of certain food groups.

What about the Grains Group might be misunderstood by Americans?

Why might it have been better to restrict starches and sugars?

What type of vegetables should people consume? Why?

How might lobbying groups, such as the National Cattlemen's Beef Association or the Soft Drink Association, impact the format of the My Pyramid?

Discuss issues related to the recommendations in the Milk Group in the My Pyramid.

Explain why the recommendations about fruit juices might be problematic.

Why is beef so high on the recommendations list considering all of the issues related to its high saturated fat content?

Discuss why it is important to make distinctions between heart healthy meat choices.

What would have been a better name for the Oils Group. Why?

Draw an example of My Pyramid that would address all of the issues discussed in this section.

Review Test

1. What year was the Basic Seven published?
   a. 1992
   b. 1956
   c. 1946
   d. 1976

2. What was the name of the first dietary recommendations presented by the United States Department of Agriculture?
   a. My Pyramid
   b. Food for Young Children
   c. The Basic Four
   d. The Basic Seven

3. The Food Guide Pyramid recommended that the vast majority of dietary intake should come from:
   a. Fats, oils, and sweets
   b. Milk, yogurt, and cheese
   c. Fruit
   d. Bread, cereal, and pasta

4. What does the color orange represent on the My Pyramid?
   a. Grains
   b. Vegetables
   c. Milk
   d. Fruit

5. The consumption of greater amounts of ____________ can be related to a greater likelihood of storing fat.
   a. Starches
   b. Fiber
   c. Sugar
   d. All of the above

6. All of the following would be examples of whole grains except:
   a. Wheat bread
   b. Gummy bears
   c. Brown rice
   d. Barley

7. Foods that contain high amounts of __________ should be avoided.
   a. Fructose
   b. Sucrose
   c. Corn syrup
   d. All of the above

8. When making vegetable choices, dark green and orange-colored vegetables are recommended.
   a. True
   b. False

9. All of the following are recommendations for ways to regulate your vegetable intake except:
   a. Eat more orange vegetables such as carrots and sweet potatoes
   b. Consume more vegetables such as corn in your diet
   c. Eat more dry beans and peas such as lentils in your diet
   d. Add more dark green vegetables such as spinach to the diet

10. One recommendation made by the My Pyramid is to consume fruit juices that are 100% real and unsweetened.
    a. True
    b. False

11. When preparing meat, it is advisable to ______________the item.
    a. Bake
    b. Grill
    c. Deep fry
    d. Broil

12. Choosing a combination of different types of lean meats will supply a variety of nutrients along with:
    a. High-quality protein
    b. Sugars
    c. Healthy fats
    d. a and b
    e. a and c

13. Oils that are solid at room temperature generally contain much ___________ fat.
    a. Monounsaturated
    b. Saturated
    c. Polyunsaturated
    d. None of the above

14. In general, the average person has between __________ discretionary calories.
    a. 500–700
    b. 400–600
    c. 300–500
    d. 100–300

15. How many minutes of physical activity a day should a person strive to get?
    a. 30
    b. 40
    c. 60
    d. 10

16. All of the following are adjustments to the My Pyramid recommendations that can help athletes except:
    a. The carbohydrate or grains group should exclusively focus on whole grains
    b. The basic recommendations for fruits and vegetables should not be modified
    c. Fish, which contains omega-3 fatty acids, should be increased in the diet
    d. Athletes need to consume more water to remain hydrated

17. One of the major problems with the My Pyramid is that it does not have any writing on it; therefore, it is difficult to understand without downloading the accessory materials from the online Web site.
    a. True
    b. False

18. The My Pyramid recommended servings for meat, poultry, dried beans, eggs, or nuts per day is:
    a. 6–11
    b. 3–5
    c. 2–3
    d. No serving sizes are recommended

19. The prevalence of meat on the My Pyramid is probably because of the strong lobby of the:
    a. Soft Drink Association
    b. National Dairy Council
    c. National Cattlemen's Beef Association
    d. Americans for Healthy Food Association

20. The My Pyramid makes very distinct recommendations about heart healthy lean choices of protein that are lower in saturated fat and cholesterol.
    a. True
    b. False

Review of Terminology

History	**My Pyramid**	**Problems with My Pyramid**
Activity	Activity	American Meat Institute
Carbohydrates	Complex Carbohydrates	Cancer
Food for Young Children	Dairy	Diabetes
Food Guide Pyramid	Discretionary Calories	Heart Disease
Moderation	Fiber	National Cattlemen's Beef Association
My Pyramid	Grain	National Dairy Council
National Food Guide	Hydrogenation	Soft Drink Association
Proportionality	Low-Fat Meats	Type 2 Diabetes
The Basic Four	Moderation	Wheat Food Council
The Hassle-Free Daily Food Guide	Monounsaturated Fat	Whole Grains
	Oils	
	Polyunsaturated Fat	
	Proportion	
	Saturated Fat	
	Simple Carbohydrates	
	Starches	
	Sugars	
	Trans Fat	
	Variety	
	Whole Grain	

Important Abbreviations

USDA	

19
Special Needs of Youth, Women, and the Elderly

Objectives

On the completion of this chapter, you will be able to:

1. Understand the nutritional issues that relate to the healthy maturation and sports participation in young athletes.
2. Discuss the primary fueling issues as they relate to the specific needs of the young athlete.
3. Explain the precursors for the development of disordered eating and eating disorders in young athletes.
4. Target sports that classically have been linked to athletes with eating disorders.
5. Apply the macro- and micronutrient guidelines to a youth population.
6. Discuss the issues of dehydration and how proper hydration affects sports performance.
7. Understand the specific dietary issues that may be related to female athletes.
8. Explain the ramifications of eating disorders and the interaction of the components of the female athlete triad.
9. Differentiate the nutritional needs of the elderly from those of younger adults.
10. Target the specific micro- and macronutrient needs of the elderly.
11. Discuss why hydration is an important consideration for the elderly individual.

Learning Exercises

Exercise 1: Youth Nutritional Issues

Organized sports for youth aged 7–11 increased by approximately ______ between the years 1993 and 2003.

Why is it difficult to offer nutritional recommendations for young athletes?

It is particularly important to give attention to youth athletes' caloric and macronutrient needs as they relate to:

1.

2.

3.

Another concern when working with youth athletes is their risk for __________.

What two micronutrient needs are important for youth athletes?

1.

2.

Exercise 2: Proper Fueling and the Youth Athlete

What is one of the largest challenges that children and youth athletes have?

Meeting the macronutrient and energy needs of all youth athletes, regardless of gender, is important for four reasons:

1.

2.

3.

4.

What is an important reason for meeting the macronutrient and energy needs of female athletes?

List five important factors that help to dictate the energy needs of adolescent athletes:

1.

2.

3.

4.

5.

What does the Estimated Energy Requirement yield? What is reported to allow?

Fill in the following table:

Life stage (years)	Active PAL EET (kcal/day)	
	Male	Female
1–2		
3–8		
9–13		
14–18		

List and describe two methods for determining if a child or youth is meeting their caloric needs:

1.

2.

From 2 years of age until the onset of puberty, growth should be ______________.

Exercise 3: Disordered Eating and Eating Disorders in the Youth

Energy needs during adolescence seem to increase, especially during the early years. If an adolescent begins to diet, what might be some ramifications of this practice?

1.

2.

3.

What are seven sports that place importance on body weight or body image that the youth participate in?

1.

2.

3.

4.

5.

6.

7.

When examining the effects of participating in sports that require weight consciousness versus those that do not, it seems that young girls display a ______% increase in eating disorder symptoms.

Fill in the following table about male adolescent wrestlers:

Time	**Harmful weight-loss methods**		
	Number of methods used per week	**%**	**Potential methods**
In season	1		
In season	2		
In season	>5		

List the two classifications of individuals who have been most studied in connection with eating disorders:

1.

2.

Fill in the following table on the prevalence of eating disorders in 1445 students from 11 Division 1 schools surveyed in Oklahoma:

Clinical condition	Prevalence (%)	
	Males	Females
Diagnosed bulimia		
Clinically significant problems with bulimia		
Clinically significant problems with anorexia nervosa		
Binge eating		
Purging behavior		

Among collegiate women athletes, _______% met the criteria for bulimia using the EAT-26 scale, ________% were considered at risk, and _______ qualified for behaviors related to bulimia when the EDIBD scale was used.

What percentage of athletes not using oral contraceptives did not report menstrual irregularities?

List five behaviors that would be considered indicative of disordered eating and eating disorders:

1.

2.

3.

4.

5.

List 12 possible symptoms associated with eating disorders or disordered eating:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.

Exercise 4: Youth Macro- and Micronutrient Recommendations

Generally, child athletes have __________ macronutrient needs than their sedentary counterparts.

Define AMDR.

Children need more ______________ and a greater complement of ________ than adults because of their physical growth patterns.

What might be a good recommendation (g/kg/day) for a child athlete?

Fill in the following table with the appropriate daily required intake values:

Life stage (years)	Carbohydrates	Proteins
	(g/day)	(g/day)
Children		
1–3		
4–8		
Males		
9–13		
14–18		
Females		
9–13		
14–18		

Match the following macronutrient with the appropriate range (%):

1. _________ Fat (child 1–3 years) A) 30–40
2. _________ Carbohydrate (child/adolescent 4–18 years) B) 45–64
3. _________ Protein (child/adolescent 4–18 years) C) 25–35
4. _________ Fat (child/adolescent 4–18 years) D) 5–10
5. _________ Carbohydrate (child 1–3 years) E) 10–20
6. _________ Protein (child 1–3 years) F) 45–65

Under what circumstance do vitamin and mineral supplements enhance sports performance?

What are the two primary minerals of concern when working with children?

1.

2.

Explain the relationship between bone formation and bone remodeling during childhood and adolescent growth. What happens by the end of puberty?

Why is it important to maximize bone mineral density at a young age?

Explain the major results that occur with 18 weeks of calcium supplementation in adolescent girls.

List two potential injuries that have been associated with inadequate calcium intake and low bone mineral densities. Define how inadequate calcium intake and low bone mineral density interact to exacerbate these injuries.

1.

2.

Fill in the following table of Dietary Reference Intakes for calcium:

	Children		**Males**	**Females**
	1–3 (years)	**4–8 (years)**	**9–13 (years)**	**9–13 (years)**
Calcium (mg/day)				

Iron is a component of two compounds that carry oxygen. What are these two compounds and where do they carry oxygen?

1. ____________________:

2. ____________________:

How does iron-deficiency anemia or nonanemic iron deficiency affect athletic performance?

Discuss the prevalence of iron deficiency in children. Include a discussion of serum ferritin.

Explain how iron supplementation affects athletic performance and serum ferritin levels.

What five factors should be measured when assessing adolescents for nonanemic iron deficiencies?

1.
2.
3.
4.
5.

Exercise 5: Youth Hydration Recommendations

What are some things that can be caused by dehydration?

1.
2.
3.

What two reasons account for the increased risk of heat illnesses in children compared with adults?

1.
2.

Explain the general consensus presented about the potential impaired thermoregulation associated with children.

Compare and contrast the ability of boys and girls to tolerate higher temperatures and humidity.

What are seven signs of dehydration and heat illness?

1.
2.
3.
4.
5.
6.
7.

Discuss some strategies to help children deal with hot and humid days. In this discussion, describe the potential benefits of commercial sports drinks.

Exercise 6: Special Recommendations for Women

What are three concerns that directly relate to women?

1.

2.

3.

List the three components of the female athlete triad:

1.

2.

3.

How prevalent is osteoporosis?

Fill in the following table with the AI and NHANES recommendations for calcium intake for women:

Age group (years)	**AI (mg/day)**	**Age group (years)**	**NHANES (mg/day)**
9–13			
14–18		12–19	
19–30		20–39	
31–50		40–59	
50–70		≥60	
>70			

Because athletic women have a risk of injury and potential for having __________ and _____________, it is important that they consume at least the AI for calcium.

Explain the relationship between the occurrence of stress fractures and bone mineral density.

Discuss the relationship between menstrual irregularities, such as amenorrhea or oligomenorrhea, and the occurrence of stress fractures.

In detail, discuss the prevalence of iron deficiencies in women aged 14–39 years.

Fill in the following table with the RDA and NHANES recommendations for iron intake:

Age group (years)	**AI (mg/day)**	**Age group (years)**	**NHANES (mg/day)**
9–13			
14–18		12–19	
19–30		20–39	
31–50		40–59	
50–70		≥60	
>70			

What is the most common factor about dietary intake of iron that affects menstruation?

Discuss the prevalence of iron deficiency without anemia in athletic women.

Exercise 7: Eating Disorders and the Female Athlete Triad

Explain the relationship between bone mineral density and menstrual dysfunction.

What are the three components of the female athlete triad?

1.

2.

3.

Discuss the types of athletes that are at the most risk of developing the female athlete triad.

Explain what steps need to be taken to treat athletes who develop the female athlete triad.

List and explain the nine potential contributing factors to the occurrence of the female athlete triad.

1.
2.
3.
4.
5.
6.
7.
8.
9.

Exercise 8: Nutritional Concerns for the Elderly

Fill in the following table based on the NHIS statistics on physical activity in the elderly:

Activity level	Men	Women
Very physically active		
Medium–highly physically active		

Define the following terms:

1. Very physically active:
2. Medium–highly physically active:

Why is it important for the older adult and elderly to be concerned with nutritional intake?

Exercise 9: Calorie and Macronutrient Needs of the Elderly

Generally, it is believed that caloric needs decrease with age, especially later in life. What are two interrelated factors that contribute to this occurrence?

1.

2.

Why is it important for older adults and the elderly to ensure that they consume adequate calories and adequate protein content in their diet?

Although there are no studies that estimate the caloric need of the elderly athlete, how can caloric needs be estimated?

Generally, resistance training ________________ the caloric needs of the elderly.

Discuss in detail the debate that revolves around the adequacy of the RDA for protein intake and its relationship to elderly individuals.

Exercise 10: Micronutrient Needs of the Elderly

What are two micronutrients that are of utmost importance to the elderly athlete?

1.

2.

The calcium intake of men and women was reported to be ________ and ________, respectively, in the NHAMES study collected between 1999 and 2000.

Discuss why vitamin D might be important for the elderly. Is a deficiency in this micronutrient related to any malady?

Why are elderly individuals at a greater risk for developing vitamin D deficiencies?

1.

2.

Only _________ of older women consume the AI for vitamin D, whereas only ______ of adults aged 51–70 and ________ of the adults older than 70 met the RDA for vitamin D through the consumption of foods alone.

Fill in the following table with the dietary reference intakes of calcium and vitamin D for the elderly:

	Calcium (mg/day)	Vitamin D (μg/day)	
Age (years)	**Men and women**	**Men**	**Women**
51–70			
>71			

Exercise 11: Hydration Needs of the Elderly

What two changes that occur with advancing age make it critical to monitor hydration status in the elderly?

1.

2.

Why are the elderly prone to dehydration?

1.

2.

3.

Define and explain hypernatremia.

What are four potential causes of hypernatremia?

1.

2.

3.

4.

It has been reported that elderly men and women have altered physiologic thirst control systems. These alterations result in what two things?

1.

2.

Explain the fluid consumption recommendations for the elderly. How much fluid should they consume and how often?

List five potential symptoms that can be indicative of hypernatremia:

1.

2.

3.

4.

5.

Review Test

1. Hyponatremia can result in:
   a. Extreme fatigue
   b. Confusion
   c. Death, in extreme conditions
   d. All of the above

2. Elderly individuals experience changes in their physiologic systems that result in a reduced thirst response to the loading and unloading of pressure receptors responsible for stimulating thirst.
   a. True
   b. False

3. The intake of ____________ is considered to be an important micronutrient of concern for children.
   a. Vitamin c
   b. Phosphorous
   c. Iron
   d. a and b
   e. b and c

4. All of the following are important reasons why it is important for young athletes to meet their caloric and macronutrient needs except:
   a. Proper caloric and macronutrient needs must be met to support growth and development.
   b. Proper caloric and macronutrient needs must be met to stimulate amenorrhea in adolescent girls.
   c. Proper caloric and macronutrient needs must be met to ensure recovery from injuries.
   d. Proper caloric and macronutrient needs must be met to meet the training demands of the sport the athlete is participating in.

5. The daily energy reference intakes for teenage males aged 14–18 should be approximately:
   a. 2071 calories
   b. 1742 calories
   c. 1046 calories
   d. 3152 calories

6. When children begin to diet, this can interfere with bone development and the onset of puberty.
   a. True
   b. False

7. Athletes who participate in __________ are considered to be at increased risk for disordered eating or eating disorders.
   a. Football
   b. Soccer
   c. Diving
   d. Tennis

8. According to scientific literature, _____ of wrestlers use two methods of harmful weight loss a week.
   a. 12%
   b. 52%
   c. 72%
   d. 92%

9. All of the following are considered harmful methods of weight loss except:
   a. Fasting
   b. Dehydration
   c. Vomiting
   d. Minor diet modification

10. To assess the prevalence of eating disorders, one could use:
   a. EAT-26 assessment tool
   b. EDI-BD assessment tool
   c. POMS assessment tool
   d. a and b
   e. b and c

11. All of the following are considered symptoms of eating disorders except:
   a. Syncope
   b. Eumenorrhea
   c. Hair loss
   d. Lanugo

12. A 9-year-old girl requires ________ grams of protein a day according to the Dietary Reference Intakes guidelines.
   a. 130
   b. 52
   c. 34
   d. 46

13. Signs that indicate an individual is dehydrated include:
   a. Apathy
   b. Cramps
   c. Dizziness
   d. Thirst

14. Women who are amenorrheic have a(an) __________ risk of bone fractures.
    a. Increased
    b. Decrease
    c. No effect

15. A woman who is 56 years old should consume ______ mg/day of iron according to the RDA.
    a. 15
    b. 18
    c. 8
    d. 20

16. All of the following are considered a part of the female athlete triad except:
    a. Eumenorrhea
    b. Amenorrhea
    c. Osteoporosis
    d. Disordered eating

17. As one ages, there is ___________ in(on) lean body mass that occurs as a result of decreasing physical activity.
    a. An increase
    b. A decrease
    c. No effect

18. The elderly have a decreased risk for vitamin D deficiency because of an increased synthesis of vitamin D and an increase in conversion of vitamin D to its active form in the kidneys.
    a. True
    b. False

19. An 80-year-old woman should consume ______ mg per day of calcium.
    a. 600
    b. 400
    c. 1200
    d. 100

20. The absence of a menstrual cycle is termed:
    a. Eumenorrhea
    b. Oligomenorrhea
    c. Amenorrhea
    d. None of the above

Review of Terminology

Proper Fueling for Youth	**Disordered Eating and the Youth**	**Macro- and Micronutrients and Youth**
Dietary Reference Intakes	Constipation	Acceptable Macronutrient Distribution Ranges
Estimated Energy Requirement	Diagnostic and Statistical Manual for Mental Disorders	Adequate Intake Reference Values
Institute of Medicine	Dietary Reference Intakes	Anemia
Macronutrient	Eating Attitudes Test	Bone Mineral Content
Micronutrient	Eating Disorder Inventory Body Dissatisfaction Subscale	Bone Mineral Density
National Center for Health Statistics	Estimated Energy Requirement	Ferritin
National Health and Nutrition Examination Survey	Institute of Medicine	Hematocrit
Physical Activity Level	Lanugo	Hemoglobin
	Macronutrient	Macronutrient
Hydration and Youth	Micronutrient	Micronutrient
Dehydration	National Center for Health Statistics	Myoglobin
Heat Cramps	National Health and Nutrition Examination Survey	Recommended Daily Allowance
Heat Exhaustion	Physical Activity Level	Total Iron Binding Capacity
Heat Stroke	Syncope	Transferrin
Heat-Related Illness		
Tachycardia	**The Female Athlete Triad**	**Hydration and the Elderly**
	Eumenorrhea	Dehydration
Special Recommendations for Women	Female Athlete Triad	Diarrhea
Amenorrhea	Oligomenorrhea	Electrolyte Homeostasis
Dual-Energy X-Ray Absorptiometry	Osteoporosis	Hypernatremia
Female Athlete Triad		Hypertension
Oligomenorrhea		Polyuria
Osteopenia		
Osteoporosis		

Important Abbreviations

AI	EER
BMC	IOM
BMD	NCHS
DEXA	NHANES
DRI	NHIS
DSM-IV	PAL
EAT-26	RDA

Part IV
Supplements

20
Sports Applications of Creatine

Objectives

On the completion of this chapter, you will be able to:

1. Understand the biochemical basis for the role of creatine in the body.
2. Recognize the dietary sources of creatine and how different dietary regimes will enhance creatine content of muscle.
3. Differentiate among the different supplementation regimes presented in the literature.
4. Understand the effects of various creatine supplementation regimes on muscular stores of creatine and phosphocreatine.
5. Explain the different theoretical rationales for why creatine supplementation might be an effective ergogenic aid.
6. Describe the ergogenic benefits most noted in the scientific literature.
7. Examine the potential clinical or therapeutic uses of creatine supplements.
8. Discuss the ethical issues involved in creatine supplementation.
9. Understand the best practices used for creatine supplementation: loading, maintenance, dosage, timing, and type of creatine supplements.
10. Discuss the differences between the lay media's reports on creatine safety and the data presented in the scientific literature.

Learning Exercises

Exercise 1: Theoretical Background for Creatine Supplementation

Define the following abbreviations:

1. ADP:
2. ATP:
3. PCr:

As phosphocreatine stores become depleted during explosive intense exercise, the a rate at which ATP is resynthesized is ____________.

Explain the basic hypothesis behind why it might be useful to increase muscular stores of phosphocreatine.

Creatine is primarily found in _______________ (~95% of creatine is found here).

Define the following terms:

1. Phosphocreatine:
2. Free creatine:
3. Total creatine pool:

The total creatine pool of a 70-kg individual is about _________ g.

The daily turnover of creatine to creatinine in the muscle is about _____% or _____ g.

What are the two ways that creatine can be replenished by the body?

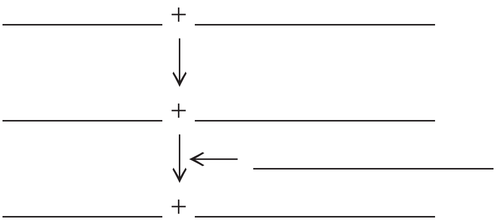
1.
2.

What three amino acids are used to synthesize creatine?

1.
2.
3.

Does the normal daily diet maintain the creatine pool? Are there any diets that do not?

Fill in the following biosynthesis pathway for creatine:



Fill in the following table based on the creatine content of selected foods:

	Creatine content	
Food	**g/lb.**	**g/kg**
Shrimp	Trace	
Cod		
Tuna		4
Salmon		
Herring	3–4.5	
Beef		
Pork		5
Cranberries		
Milk	0.05	

The enzyme creatine kinase catalyzes the reversible reaction between ______ and ______.

What are the two subunit types of creatine kinase?

1.

2.

List and define the four isoforms of creatine kinase:

1.

2.

3.

4.

Which subunits and isoforms of creatine kinase are the most active?

In the table below, fill in the characteristics of slow-twitch muscle fibers in relationship to the types of creatine kinase:

Fast-twitch fibers	Slow-twitch fibers

The resynthesis of phosphocreatine might be a critical factor in sustained ___________________.

Discuss in detail the concept of the creatine phosphate shuttle system.

Explain the basis for the theory that the resynthesis of PCr is likely to be oxidative in origin.

Exercise 2: Creatine Supplementation Protocols

The most typical loading regime presented in the literature suggests that ______ grams of creatine per kilogram body mass per day needs to be consumed for ______ days.

The typical loading regime can increase muscular stores of creatine and phosphocreatine by ______%.

After the loading phase, it is typical to consume between _________ g of creatine per day to maintain these stores.

In the table below, list the four proposed creatine supplementation regimes and their positive and negative attributes:

Supplementation plan	Dosage	Duration	Positive attributes	Negative attributes

How long does it take for creatine supplement–induced increases in muscular stores of creatine to return to baseline after supplementation is ceased?

If you add carbohydrate or protein to the creatine supplement, what happens to the duration needed to maximize the muscular stores of creatine and phosphocreatine?

Exercise 3: Effects of Creatine Supplementation on Muscle Creatine Stores

The implementation of a creatine supplementation regime has been consistently shown to result in a _______% increase in muscular stores of creatine and phosphocreatine.

Differentiate the effectiveness of creatine supplementation between individuals with low and high natural stores of creatine.

The larger the increase in creatine stores, the ____________ in performance.

Is there evidence that long-term creatine supplementation results in a suppression of endogenous creatine synthesis?

Exercise 4: Theoretical Benefits of Creatine Supplementation

List and describe the two major theories about how creatine supplementation might benefit a strength/power athlete:

1.

2.

Describe how creatine supplementation might theoretically enhance endurance performance.

In the table below, give examples of sports that would be enhanced by the theoretical method presented:

Theoretical mechanism of enhancement	Example sports
Increased phosphocreatine	1. 2. 3.
Increased phosphocreatine resynthesis	1. 2. 3. 4. 5. 6.
Reduced muscle acidosis	1. 2. 3. 4.
Oxidative metabolism	1. 2. 3. 4. 5. 6.
Enhanced training	1.
Increased body mass/muscle mass	1. 2. 3. 4. 5. 6. 7.

List seven potential ergogenic benefits of creatine supplementation:

1.
2.
3.
4.
5.
6.
7.

Exercise 5: Effects of Creatine on Exercise Performance or Training

In the scientific literature, there are approximately 1000 articles in peer-reviewed journals, ______% of which suggest that creatine produces significant improvements in performance.

Fill in the table with average performance gains as a result of creatine supplementation:

	Percent increase in performance
Short-term creatine supplementation	
Maximal power/strength	
Work performed during sets of maximal contraction	
Single-effort sprint performance	
Work performed during repetitive sprinting	
Long-term creatine supplementation	
Strength gains	
Fat-free mass	

One of the most noted effects of creatine supplementation is an _______ in body mass.

Summarize some of the more recent studies on the short-term effects of creatine supplementation.

Summarize some of the more recent studies on the long-term effects of creatine supplementation.

Exercise 6: Potential Therapeutic Uses of Creatine Supplementation

Initial research focused on the effects of creatine on what two heart ailments?

1.

2.

List three medical conditions in the population that involve deficiencies in creatine content:

1.

2.

3.

What are nine clinical conditions in which researchers have investigated the effectiveness of creatine supplementation on clinical outcomes?

1.

2.

3.

4.

5.

6.

7.

8.

9.

Exercise 7: Common Questions about Creatine Supplementation

The popular literature reports the following side effects of creatine supplementation:

1.
2.
3.
4.
5.
6.

Contrary to the popular literature, what has the peer-reviewed scientific literature revealed about creatine supplementation?

Discuss the best form of creatine to use in a supplement. Is creatine monohydrate the best?

Which country produces creatine with the least impurities?

Which countries are the best sources of raw creatine monohydrate? Provide examples.

Why is it important for athletes to undertake a loading regime when supplementing?

How is creatine absorbed and or excreted?

What mechanism is most often cited as the method of creatine uptake in muscle?

What is the best method for increasing creatine uptake by muscle? What should be taken with creatine?

When is the best time to take creatine?

When should an athlete take creatine? Should an athlete cycle their creatine use?

Do women get the same effects from creatine supplementation as men?

What is the water content of muscle?

Differentiate between long- and short-term weight gain? Is it muscle mass gain?

What seven conditions would indicate that a child or teenager should take creatine?

1.
2.
3.
4.
5.
6.
7.

Overall, what is the general consensus on the safety of creatine supplementation?

Discuss the ethical considerations that are typically presented regarding creatine supplementation.

Review Test

1. Long-term (<5 years) evaluations about safety have revealed that creatine supplementation results in:
   a. Increased occurrence of muscle strains
   b. Increased incidence of muscle cramping
   c. The development of anterior compartment syndrome
   d. Nonmeasurable side effects

2. The effect of taking carbohydrate and creatine together on the amount of creatine stored in the muscle:
   a. Increased
   b. Decreased
   c. No effect

3. The most effective way to rapidly increase muscular stores of creatine is to follow a low-dosage creatine regime in which 5–6 g of creatine are taken for 10–12 weeks.
   a. True
   b. False

4. All of the following are true about the effects of creatine supplementation in women except:
   a. Women are less interested in creatine supplementation than men
   b. Women tend to gain body mass less rapidly than men when supplementing
   c. Women tend to gain lean body mass more rapidly than men when supplementing
   d. Women experience ergogenic gains when taking creatine

5. The greatest numbers of impurities in creatine supplements are found in creatine from:
   a. China
   b. Germany
   c. United States
   d. None of the presented countries

6. All of the following have been reported to be effects of 12 weeks of creatine supplementation (6 g/day) coupled with a resistance-training program except:
   a. Increases in myosin heavy chain mRNA expression
   b. Increases in fat mass
   c. Increases in type IIx fiber content
   d. Increases in thigh volume

7. Short-term studies on creatine supplementation have reported an average increase of _______ in single-effort sprint performance.
   a. 5%–15%
   b. 10%–15%
   c. 1%–5%
   d. 0%

8. Short-term studies suggest that during the first week of creatine loading, there is a ____ increase in body mass.
   a. 2- to 4-kg
   b. 4- to 8-pound
   c. 10-kg
   d. 1- to 2-kg

9. Creatine supplementation could offer an ergogenic benefit by:
   a. Enhanced glycogenolysis
   b. Enhanced recovery from training
   c. Increased work capacity
   d. a and b
   e. b and c

10. Of the 1000 articles published regarding creatine supplementation, approximately 70% of them suggest that creatine supplementation produces ergolytic effects.
    a. True
    b. False

11. Which sport might show enhanced performance by creatine supplementation via improvements in oxidative metabolism?
    a. Weightlifting
    b. Bodybuilding
    c. Soccer
    d. Rowing

12. Creatine supplementation has traditionally been recommended for endurance athletes.
    a. True
    b. False

13. Jon is 70 kg and he wants to undertake a 5- to 7-day loading regime. How much creatine should he take?
    a. 21 g
    b. 3 g
    c. 5 g
    d. 25 g

14. Loading regimes need to last:
    a. 5–7 days
    b. 2–3 days
    c. 28 days
    d. a and b
    e. a and c

15. The effects of taking 0.3 g/kg/day of creatine for 5–7 days on muscular stores of creatine and PCr:
    a. Increase
    b. Decrease
    c. No effect

16. The primary energy system used in a 40-m sprint is:
    a. ATP/PCr system
    b. Aerobic glycolysis
    c. Phosphagen system
    d. a and b
    e. a and c
    f. None of the above

17. Vegetarians have higher concentrations of creatine than those who eat animal products.
    a. True
    b. False

18. Creatine supplementation has been reported to result in a ___________ increase in muscular stores of creatine and PCr.
    a. 50%–80%
    b. 30%–60%
    c. 10%–40%
    d. 0%–10%

19. Creatine supplementation has been shown to enhance fat oxidation during short-burst activities such as interval training.
    a. True
    b. False

20. After stopping creatine supplementation, it takes ________ until the muscular stores of creatine return to baseline.
    a. 1 week
    b. 2 weeks
    c. 3 weeks
    d. 4 weeks

Review of Terminology

Theoretical Background	**Supplementation Protocols**	**Effect on Muscle Stores**
Adenosine Diphosphate	Creatine Monohydrate	Creatine Synthesis
Adenosine Triphosphate	Cycling Program	Endogenous
Creatine Kinases	Loading Phase	
Free Creatine	Maintenance Phase	**Theoretical Benefits of Supplementation**
Phosphagen Energy System	**Effects of Creatine Supplementation**	Acidosis
Phosphocreatine	Calcium-beta-hydroxy-beta-methylbutyrate	Ergogenic
Total Creatine Pool	Fat-Free Mass	Mitochondria
	Myofibrillar Protein Content	Oxidative Metabolism
Therapeutic Uses of Creatine	Myogenin	
Amyotrophic Lateral Sclerosis	Myosin Heavy Chain	**Common Questions**
Arrhythmias	Type I	Anterior Compartment Syndrome
Atrophy	Type IIa	
Diabetes		
Gyrate Atrophy		
Homocysteine		
Huntington's Disease		
Ischemia		
Muscular Dystrophy		
Myopathies		

Important Abbreviations

ACS	MHC
ADP	Mi-CK
ATP	MM-CK
CK	MRF-4
FFM	mRNA
HMB	PCr
MB-CK	

21
Weight Loss Ingredients

Objectives

On the completion of this chapter, you will be able to:

1. Understand why weight loss ingredients are so popular.
2. Explain the current obesity trends in the United States.
3. Discuss the origin and theoretical mechanisms of function for a series of weight loss ingredients.
4. Differentiate between the proposed and actual scientifically proven effects of a variety of weight loss ingredients.
5. Understand the potential ramifications of using weight loss ingredients.

Learning Exercises

Exercise 1: Overview of Obesity and Dietary Supplements

What percentage of the population is considered obese or overweight?

A BMI of 25–29.9 kg/m^2 = ____________________.

A BMI of ≥30 kg/m^2 = ______________________.

List seven potential major health problems that might be linked to being overweight or obese.

1.
2.
3.
4.
5.
6.
7.

If an individual is overweight or obese, what must they do to lose weight?

What three modifications are generally recommended for successful weight loss to occur?

1.
2.
3.

List two last-resort methods for reducing body weight:

1.
2.

In 2002, consumers spent approximately _________ on weight loss products.

Exercise 2: Citrus aurantium

Citrus aurantium is also known as ___________________.

Describe where *Citrus aurantium* comes from.

What are the two active components of *Citrus aurantium*, which are considered the "chemical cousins" of ephedra? Which is in higher concentrations?

1.

2.

List the three alkaloids that are contained in *Citrus aurantium*.

1.

2.

3.

It has been suggested that synephrine should be in higher concentrations in fat loss supplements because it stimulates the β receptors. Describe the three β receptors:

1. β-1:

2. β-2:

3. β-3:

Which β receptor would you want to up-regulate because it is responsible for lipolytic and thermogenic effects? Does *Citrus aurantium* activate this β receptor?

Explain the current body of knowledge about the effectiveness of *Citrus aurantium* on weight loss.

Exercise 3: Green Tea

________ is the most widely consumed beverage in the world, whereas green tea is the second most widely consumed beverage in the world.

The extract of which one of the four catechins found in green tea seems to show promise as a weight loss tool? How is it abbreviated?

Collectively, _________ and ________ are considered catecholamines, which are potent regulators of ________ and ________.

Under what situations are the catecholamines released?

List two things that occur in response to catecholamine release:

1.

2.

Which catecholamine is quickly hydrolyzed by COMT? What does this cause to happen?

Which catecholamine usually activates adenylate cyclase by binding to a receptor and up-regulating the enzyme?

The activation of adenylate cyclase results in the conversion of ________ to cAMP.

What hormone does cAMP activate? What is this hormone quickly degraded to? Which enzyme stimulates this to occur?

How does the ingestion of green tea relate to the activity of hormone sensitive lipase?

How does caffeine effect the actions of phosphodiesterase? How does this relate to hormone sensitive lipase?

Discuss the general scientific evidence on the effectiveness of green tea as an ergogenic aid.

Exercise 4: Caffeine

Discuss the three methods by which caffeine exerts its effects as a weight loss supplement.

1.

2.

3.

Discuss the physiologic effects of caffeine supplementation on:

1. Energy expenditure:
2. Lipid turnover:
3. Lipid oxidation:
4. Lipolysis:

The ingestion of high doses of caffeine can result in:

1.

2.

3.

4.

5.

Caution is recommended when consuming caffeine doses that are >________ mg, which corresponds to approximately _____ cup(s) of coffee.

Exercise 5: Conjugated Linoleic Acids

What are three things that conjugated linoleic acid has been proposed to do?

1.

2.

3.

Define what is meant by positional and geometric isomers.

In what dietary sources is CLA usually found? Give some examples.

Fill in the following table:

Gender	Dietary intake (mg/day)
Men	
Women	

The most biologically active form of CLA is ________________________.

List the four most common commercial preparations of CLA:

1.
2.
3.
4.

Compare and contrast the effects of CLA supplementation on body composition in animal and human models.

Based on a recent meta-analysis examining studies with CLA supplement dosages that ranged from 1.4 to 6.8 g/day, what can be concluded?

The dietary form of CLA is primarily ___________, but most research has looked at _____________ or _____________. Could this be a problem? Please explain.

Based on the available literature comparing supplements made from different forms of CLA, what can be concluded?

Compare the dosages used in human studies with those used in animals. Why have the same dosages not been used?

Discuss the long-term effects of long-term CLA use.

What population seems to experience the greatest ergogenic effects from CLA supplementation?

Exercise 6: Chitosan

Chitosan is suggested to ________________.

Where is chitosan extracted from, and what is it?

Theoretically, what is the goal of chitosan use? What pharmaceutical agent is it similar to?

Summarize the current scientific knowledge about the effects of chitosan. Is it ergogenic?

What is one common side effect associated with chitosan supplementation? Why does this happen?

Exercise 7: Chromium

What is chromium?

Is chromium a popular supplement? Is its sale profitable?

Chromium is also referred to as ______________, and is part of a complex that is found in the body that enhances the effectiveness of __________.

List some of the better sources of chromium in the diet:

1.

2.

3.

4.

Individuals who are chromium deficient exhibit signs of:

1.

2.

What diseases has chromium been suggested as a treatment for?

1.

2.

Initially, it was thought that chromium acts in the body by augmenting the cell's sensitivity to insulin. Why is this important?

Based on current scientific knowledge, how effective is chromium supplementation?

Exercise 8: Coleus forskohlii

What is *Coleus forskohlii*?

In ancient times, what was *Coleus forskohlii* used to treat?

1.

2.

What constituent levels are supplement manufacturers elevating when producing *Coleus forskohlii*?

What is the theoretical mechanism behind *Coleus forskohlii* supplementation?

Based on current literature, is *Coleus forskohlii* an effective ergogenic aid?

Exercise 9: Hydroxycitric Acid

HCA is produced from the rind of __________, which is a fruit native to India.

What is the theoretical mechanism by which HCA is suppose to work?

Does the supplementation of HCA result in increases in plasma HCA levels?

Compare and contrast the effects of HCA in animal and human models.

Based on the current knowledge base, what can be concluded about HCA?

Exercise 10: Ephedra

In what year was ephedrine and ephedra banned in the United States?

Why were ephedrine and ephedra banned?

Ephedrine is what type of drug? What does it stimulate?

Give an example of a drug that is structurally related to ephedrine.

What are two reasons that ephedrine has become popular as a weight loss compound?

1.

2.

Why does ephedrine improve sports performance and increase alertness?

What is the difference between ephedra and ephedrine?

Why is it difficult to standardize ephedra content in supplements?

The effectiveness of ephedra as a weight loss supplement is enhance by:

1.

2.

Discuss the effectiveness of ephedrine, ephedrine plus caffeine, ephedra and ephedra plus caffeine on the promotion of weight loss.

Give examples of the potential negative effects of ephedra alkaloid use.

Exercise 11: Summary

Fill in the following table with the potential mechanism of action for each listed supplement:

Supplement	Potential mechanism
Citrus aurantium	
Ephedra	
Green tea (EGCG)	
Caffeine	
Conjugated linoleic acid	
Supplement	**Potential mechanism**
Chitosan	
Chromium	
Hydroxycitric acid	

Review Test

1. Jolene has a BMI of 25, therefore she is classified as being obese.
   a. True
   b. False

2. *Citrus aurantium* has __________ as one of its most active components.
   a. Ephedra
   b. Synephrine
   c. Octopamine
   d. a and b
   e. b and c

3. Synephrine stimulates the _____ receptors.
   a. β-1
   b. β-2
   c. β-3
   d. β-4

4. Green tea extract has been shown in vitro to inhibit:
   a. HSL
   b. COMT
   c. cAMP
   d. ATP

5. The effect of caffeine on the activity of the enzyme phosphodiesterase:
   a. Increase
   b. Decrease
   c. No effect

6. The catecholamines include:
   a. Epinephrine
   b. Norepinephrine
   c. Hormone sensitive lipase
   d. a and b
   e. b and c

7. All of the following are true about caffeine except:
   a. Caffeine stimulates energy expenditure via the parasympathetic nervous system
   b. Caffeine inhibits phosphodiesterase, allowing for hormone sensitive lipase to remain active longer
   c. Caffeine is also present in green tea and seems to work synergistically with EGCG
   d. Caffeine increases energy expenditure, lipid turnover, and oxidation

8. High-dose caffeine consumption has the potential to:
   a. Increase heart rate
   b. Elicit loose bowels
   c. Decrease blood pressure
   d. Result in diuresis

9. The most common nutritional supplement forms of conjugated linoleic acid are from:
   a. Trans-9-CLA
   b. Cis-9
   c. Trans-10-CLA
   d. Cis-13-CLA

10. Conjugated linoleic acid can be found in:
    a. Skim milk
    b. Beef
    c. Lamb
    d. a and b
    e. b and c

11. Chitosan supplementation has been shown to result in large decreases in body mass when coupled with an exercise regime.
    a. True
    b. False

12. Chromium-deficient humans also exhibit signs of:
    a. High blood pressure
    b. Hypocholesterolemia
    c. Insulin resistance
    d. Hypothyroidism

13. All of the following are considered dietary sources of chromium except:
    a. Liver
    b. Brewer's yeast
    c. Meats
    d. Milk

14. Chromium supplementation results in:
    a. No significant changes in muscular strength
    b. Significant decreases in body fat
    c. Significant increases in lean body mass
    d. Significant reductions in body mass

15. *Coleus forskohlii* stimulates the ________ enzyme.
    a. Phosphodiesterase
    b. Adenylate cyclase
    c. Lipoprotein lipase
    d. Hexokinase

16. Hydroxycitric acid is produced from the rinds of:
    a. Florida oranges
    b. Lemons
    c. *Garcinia cambogia*
    d. Limes

17. The effect of consuming hydroxycitric acid on plasma levels of HCA:
    a. Increased
    b. Decreased
    c. No effect

18. The sale of ephedrine-containing supplements or compounds was banned in _______ in the United States.
    a. 1999
    b. 2001
    c. 2005
    d. 2004

19. The effectiveness of ephedrine as a weight loss supplement is enhanced by:
    a. Caffeine
    b. Aspirin
    c. Creatine
    d. a and b
    e. a and c

20. Ephedrine is an effective weight loss supplement that causes equal amounts of weight loss to those seen with prescription drugs such as sibutramine, phentermine, and orlistat.
    a. True
    b. False

Review of Terminology

Overview of Obesity	***Citrus aurantium***	**Green Tea**
Cancer		5-Adenosine Monophosphate
Dyslipidemia	Hordenine	Adenosine Triphosphatase
Hypertension	m-Methyltyramine	Adenylate Cyclase
Obesity	Octopamine	Caffeine
Osteoarthritis	Synephrine	Catechins
Overweight	Tyramine	Catechol *O*-methyltransferase
Sleep Apnea		Catecholamines
	Caffeine	Cyclic Adenosine Monophosphate
Conjugated Linoleic Acid	Adrenaline	Epigallocatechin-3-gallate
Cis-12-CLA	Diuresis	Epinephrine
Cis-9	Energy Expenditure	Glycogen Catabolism
Cis-9 Trans-11-CLA	Lipid Oxidation	Hormone Sensitive Lipase
Geometric Isomers	Lipid Turnover	Hydrolyzed
Linoleic Acid	Lipolysis	Lipolysis
Linolenic Acid	Sympathetic Nervous System	Norepinephrine
Positional Isomers	Triglycerides	Phosphodiesterase
Rumenic Acid		
Trans-10	**Chitosan**	**Chromium**
Trans-11-CLA	Chitin	Glucose Tolerance Factor
	N-deacetylated	
Hydroxycitric Acid	Orlistat	
Acetyl-CoA		
ATP Citrate-Lyase		
Extramitochondrial		
Garcinia cambogia		
Lipogenesis		
Oxaloacetate		

Important Abbreviations

5-AMP	CLA
ATP	COMT
β-1	EGCG
β-2	GTF
β-3	HSL
cAMP	PDE

22
An Overview of Sports Supplements

Objectives

On the completion of this chapter, you will be able to:

1. Understand the common reasons that individuals take different supplements.
2. Differentiate between various dietary supplements.
3. Determine the efficacy of using certain dietary supplements.
4. Understand the mechanisms of actions associated with common dietary supplements.
5. Appropriately determine supplementation protocols based on the scientific literature.
6. Know the various common names used to represent specific supplements.

Learning Exercises

Exercise 1: 4-Hydroxyisoleucine

What are five other names for 4-hydroxyisoleucine?

1.

2.

3.

4.

5.

List five common uses for this supplement:

1.

2.

3.

4.

5.

In vitro studies demonstrate that 4-hydroxyisoleucine ____________ the secretion of insulin in a glucose-dependent manner.

Explain the effects of coadministration of 4-OH-Ile and glucose.

The combination of glucose and Promilin stimulates a _________ muscle glycogen resynthesis rate compared with glucose alone.

What two compounds does 4-OH-Ile share the same molecular formula with?

1.

2.

Considering dose schemes, what are the doses that correspond to the following situations?

1. Glucose disposal:
2. Glycogen resynthesis:

Exercise 2: 5-Hydroxytryptophan

List five other names for 5-hydroxytryptophan:

1.
2.
3.
4.
5.

What are five common uses for 5-hydroxytryptophan?

1.
2.
3.
4.
5.

Which neurotransmitter is 5-hydroxytryptophan a precursor for?

5-Hydroxytryptophan is most often found in the form of ____________ ______________ in dietary supplements.

What two conditions does 5-HTP supplementation seem to have some positive effects on?

1.
2.

Explain the process by which 5-HTP increases cortisol release and leuteinizing hormone release in men.

Discuss how 5-HTP could be used to increase the anabolic signal stimulated by resistance training.

Outline the appropriate dose scheme for 5-HTP:

1. Exercise and recovery or general use:
2. Fibromyalgia:
3. Appetite control:

Exercise 3: Adenosine Triphosphate

List seven alternative names for adenosine triphosphate:

1.
2.
3.
4.
5.
6.
7.

Discuss the common uses associated with adenosine triphosphate.

Summarize the current research data on the effectiveness of ATP supplementation. Are there enough data to make a conclusive decision on the supplement's ergogenic effects or dosage scheme?

Exercise 4: Alanine

List six alternative names for alanine.

1.
2.
3.
4.
5.
6.

Discuss the common uses of alanine.

Alanine is classified as a ______________.

Alanine is produced from a transamination of ____________.

Alanine is considered the most important amino acid involved in what process?

Alanine is considered a glucose precursor similar to ________ and _________.

What percent of the total energy-generating requirements during exercise is alanine responsible for? How does Alanine contribute?

Why and how does alanine contribute to preserving muscle tissue and supporting healthy blood glucose levels?

Discuss why alanine might be a useful supplement for persons with diabetic complications?

Outline the appropriate dosage scheme for alanine when glucose sparing and protein synthesis are the major focus.

Exercise 5: Alpha-Glycerol Phosphoryl Choline

Alpha-glycerol phosphoryl choline is also known as:

1.
2.
3.
4.
5.
6.
7.

List four common uses for alpha-glycerol phosphoryl choline:

1.
2.
3.
4.

When alpha-GPC is metabolized, it produces _____________, a water-soluble B vitamin. Explain what this metabolite does.

What are some of the effects of alpha-GPC supplementation?

Outline a dosing scheme for:

1. Cognitive function:
2. Growth hormone secretagogue:

Exercise 6: Alpha-Ketoglutarate

List 13 alternative names for alpha-ketoglutarate:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.

Alpha-ketoglutarate is often used for what two purposes?

1.
2.

AKG is the ______________ of glutamine catabolism and a precursor to ___________ synthesis.

What is AKG's most recognized function when taken orally?

Discuss some of the potential effects of supplementation with AKG.

Outline a dosage scheme for:

1. Anticatabolism:
2. General ergogenic effects:

Exercise 7: Alpha-Ketoisocaproate

List 10 alternative names for alpha-ketoisocaproate:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

What are four common uses for alpha-ketoisocaproate?

1.
2.
3.
4.

KIC is essentially a branched-chain amino acid that contains a keto group instead of an amino group; therefore, it is termed a ______________.

KIC is used both for the synthesis of, and synthesized from, _______________.

Which amino acid is KIC a keto acid of? ________________. How much of the consumed dosage is converted to this compound? ___________.

Why is KIC often used to assess protein synthesis?

What compound that has anabolic and anticatabolic effects is KIC a direct precursor to?

What are the effects of KIC on insulin?

When KIC is transaminated within the mitochondria with glutamate, what two things are created?

1.

2.

Discuss the effects of KIC supplementation in human and animal models?

Outline a postexercise recovery supplementation scheme:

Exercise 8: Alpha-Lipoic Acid

What are some alternative names for alpha-lipoic acid?

1.	2.	3.
4.	5.	6.
7.	8.	9.
10.	11.	12.
13.	14.	

List four common uses for ALA:

1.	2.	3.	4.

In what food substance is ALA found in abundance?

Explain the primary function that ALA has.

What are the ergogenic effects of ALA supplementation?

Outline a supplementation scheme for ALA:

1. Antioxidant:
2. Insulin mimetic:

Exercise 9: Androst-4-ene-3,6,17-trione

List six alternative names fro Androst-4-ene-3,6,17-trione:

1.	2.
3.	4.
5.	6.

What are two common uses for androst-4-ene-3,6,17-trione?

1.
2.

What are the in vitro effects of androst-4-ene-3,6,17-trione?

Exercise 10: Arginine

List six alternative names for arginine:

1.	2.
3.	4.
5.	6.

What are six common uses for arginine?

1.	2.
3.	4.
5.	6.

What two compounds is arginine synthesized from?

1.
2.

List three substances in which arginine is used as a precursor for:

1.
2.
3.

Explain why it is believed that arginine receives almost all of its benefits from nitric oxide.

Discuss why arginine might be useful in speeding recovery from traumatic injury.

What are the effects of arginine supplementation on clinical populations, and on athletes?

Outline a supplement dosage scheme for the following:

1. Exercise recovery:
2. Endurance performance:
3. Erectile dysfunction:
4. Growth hormone secretagogue:

Exercise 11: Asparagine

List seven alternative names for asparagines:

1.	2.
3.	4.
5.	6.
7.	

Asparagine is often used in an attempt to increase ____________ while also operating as an _______ agent.

What type of amino acid is asparagine?

Explain what asparagine assists with.

Explain the current understanding of asparagine's effects. Are these documented in animal or human studies?

Exercise 12: Aspartic Acid

List six alternative names for aspartic acid:

1.	2.
3.	4.
5.	6.

What are the two common reasons for using aspartic acid?

1.

2.

Aspartate is a nonessential, dicarboxylic amino acid that is vital for what? Why?

Explain the things that aspartate contributes to.

In the 1950s, it was suggested that aspartate could do what?

What are the three forms of aspartate, and which one might be required to elicit an ergogenic effect?

1.

2.

3.

Exercise 13: Avena sativa

List 12 alternative names for *Avena sativa:*

1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.

What are five common uses of *Avena sativa*?

1.	2.
3.	4.
5.	

Avena sativa is the Latin name for what?

After *Avena sativa* is washed in an alcohol solution, it is said to act as a:

1.
2.
3.
4.
5.
6.

What seven things does *Avena sativa* contain?

1.
2.
3.
4.
5.
6.
7.

Exercise 14: Banaba

What are some alternative names for banaba?

1.	2.
3.	4.
5.	6.
7.	8.
9.	

What is banaba? Where does it come from?

Banaba has been shown to _______________ uptake by the adipocytes, in vitro, in a dose-dependent and selective response similar to that of insulin.

What happens to the effects stimulated by banaba when insulin is present?

How does banaba affect GLUT4 and PPARγ2?

Why is banaba a possible supplement for Type II diabetics?

Outline a banaba supplementation regime for insulin mimetic.

Exercise 15: Bee Pollen

Bee pollen is also known as ___________________.

List four common uses for bee pollen:

1.
2.
3.
4.

Describe what bee pollen is.

Which natural plant antioxidant comes from bee pollen?

What are the performance effects of bee pollen? Aerobic? Anaerobic?

Exercise 16: Beta-Alanine

What are five alternative names for beta-alanine?

1.	2.
3.	4.
5.	

List five common uses for beta-alanine:

1.	2.
3.	4.
5.	

What are five things that contain beta-alanine?

1.	2.
3.	4.
5.	

Discuss the effects of beta-alanine supplementation in humans.

Why should taurine be supplemented in conjunction with beta-alanine?

Outline a supplement dosage scheme designed for protein buffering for beta-alanine.

Exercise 17: Betaine

List 11 alternative names for betaine:

1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	

Betaine is a metabolite of ____________ and _________________.

What are some food sources that are rich in betaine?

1.	2.
3.	4.
5.	6.

List and explain the two main functions of betaine in the body.

1.

2.

Why is betaine an important nutrient for the prevention of chronic disease?

What happens to homocysteine levels in response to betaine supplementation?

Describe a betaine supplementation regime that targets protein or general use.

Exercise 18: Beta-Hydroxy-Beta-Methylbutyrate

List seven alternative names for beta-hydroxy-beta-methylbutyrate:

1.
2.
3.
4.
5.
6.
7.

Explain what HMB is, and how it is formed.

When HMB is metabolized:

HMB ⇒ ____________ ⇒ acetoacetate

This process supports what three things:

1.
2.
3.

What are three ergogenic effects of HMB?

1.
2.
3.

Explain what happens when HMB and creatine are combined.

Detail the effects of HMB supplementation in the elderly.

Outline an HMB supplementation regime designed to be anticatabolic and increase muscle strength.

Exercise 19: Branched-Chain Amino Acids

What are some additional names for branched-chain amino acids?

1.	2.
3.	4.
5.	6.

List some of the common uses for branched-chain amino acids:

1.
2.
3.
4.
5.
6.
7.
8.

What are the three essential amino acids that comprise the branched-chain amino acids?

1.
2.
3.

BCAAs comprise __________ of the total muscle protein pool.

Match the source of BCAAs with the corresponding percentage:

___________ Whey protein A) 10%

___________ Milk protein B) 26%

C) 21%

Under what conditions are BCAAs primarily oxidized?

List and explain the major effects of BCAA supplementation regardless of when they are ingested:

1. ________________:
2. ________________:
3. ________________:

Why is it important to ensure that pyridoxine intake is increased when supplementing with BCAAs?

Describe a BCAA supplementation protocol designed to be anabolic and anticatabolic, to enhance glycogen resynthesis, and to be an insulin mimetic.

Exercise 20: Carnosine

List three alternate names for carnosine.

1.
2.
3.

What are some common uses for carnosine?

1.
2.
3.
4.
5.
6.
7.

Explain what carnosine is and where it is primarily found.

What is the theoretical or proposed benefit of increasing histidine dipeptides?

Discuss the relationship between muscle levels of carnosine and exercise performance.

Does carnosine operate as an antioxidant?

Outline two supplement regimes for the following:

1. Proton buffering:
2. Antioxidant and general use:

Exercise 21: Choline

Choline is also known as ______________, ____________, and _________________.

Some common uses for choline include ______________, _______________, __________, and _________________.

Is choline characterized as an essential nutrient?

What is choline's specific function or role?

What are the two most common food sources that are high in choline?

1.
2.

The most prevalent form of choline is _________________, which is the phospholipid form.

What does the current literature suggest about the effects of choline supplementation on performance?

Detail a choline supplementation regime that is designed for general use.

Exercise 22: Chondroitin Sulfate

List nine alternative names for chondroitin sulfate:

1.	2.
3.	4.
5.	6.
7.	8.
9.	

What are some of the common uses of chondroitin sulfate?

1.

2.

3.

4.

Chondrotin sulfate operates as a glycosaminoglycan resulting in the formation of ______________________, which along with __________, comprise the two most important components of connective tissue.

Long-term loading and unloading such as that seen in resistance training can produce _______________ such as ________________.

Summarize the current literature that examines the effects of chondroitin sulfate supplementation in older adults.

What compound is chondroitin sulfate often coadministered with? Are there data to support this practice?

Detail a chondroitin sulfate supplementation regime designed to enhance joint health and act as an analgesic.

Exercise 23: Chrysin

Chrysin is also known as:

1.	2.
3.	4.
5.	6.

What is chrysin?

Where does chrysin come from?

Where is chrysin frequently found?

Summarize the current literature about the effectiveness of chrysin on circulating testosterone and endogenous estrogen.

When chrysin is ingested orally, only __________% is metabolized systemically, whereas __________% of the ingested compound is excreted from the body.

Exercise 24: Citrulline

List 10 alternative names for citrulline:

1.	2.
3.	4.
5.	6.
7.	8.
9.	10.

What are some common uses for citrulline?

1.
2.
3.
4.
5.

What is citrulline?

Citrulline is derived from ___________ during NO synthase.

Citrulline can be used to form ____________ via the ______________ cycle.

What is the relationship between citrulline and lactate, and exercise intensity?

Discuss how citrulline effects lactate reabsorption?

What does combining citrulline with malate allow for?

Citrulline increases ____________________, whereas DL-malate facilitates ___________ via its role as a TCA cycle intermediate.

Outline a dosage scheme for citrulline.

Exercise 25: Coenzyme Q10

Coenzyme Q10 is also known as:

1.	2.
3.	4.
5.	6.
7.	8.
9.	10.

Describe what CoQ10 is and what it does.

What are some of the positive benefits of supplementing with CoQ10?

Describe the effects of using CoQ10 on gene expression and fiber type.

Outline a supplementation scheme for CoQ10.

Exercise 26: Conjugated Linoleic Acid

List some alternative names for conjugated linoleic acid:

1.	2.
3.	4.
5.	6.
7.	

Conjugated linoleic acid is used for:

1.
2.
3.
4.

What are some sources of CLA?

What fatty acid is CLA related to?

Explain what cis-9, trans 11 is frequently used for.

Explain what trans-10, cis-12 is frequently used for.

Under what conditions is CLA supplementation most effective?

What are some potential problems with CLA supplementation?

Exercise 27: Cordyceps

Cordyceps is also known as:

1.	2.
3.	4.
5.	6.
7.	8.

Cordyceps is frequently used in an attempt to:

1.
2.
3.
4.
5.

What is Cordyceps?

Cordyceps is an adaptogen that is used to increase:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

The primary active ingredients of Cordyceps are:

1.
2.
3.
4.
5.

Glucose, mannose, and galactose are the principal parts of the ______ _________ portion of Cordyceps.

Describe the differences between synthetic Cordyceps and naturally occurring Cordyceps.

What is the most common commercially available form of Cordyceps?

Discuss the effects of Cordyceps supplementation.

Outline a Cordyceps supplement scheme that focuses on:

1. Adaptogen and general use:
2. Endurance performance:

Exercise 28: Cysteine

Cysteine is also known as:

1.	2.
3.	4.
5.	6.
7.	8.

What are six common uses for cysteine?

1.
2.
3.
4.
5.
6.

Cysteine is most often referred to as _____________, which is a component of sulfur in a variety of foods.

Why is cysteine considered to be a conditionally essential amino acid?

What happens to cysteine in response to exercise?

What happens to glutathione concentrations in response to oral cysteine supplementation?

Exercise 29: Digestive Enzymes

Digestive enzymes are also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
Digestive enzymes are also known as:	
11.	12.
13.	14.
15.	16.
17.	18.
19.	20.
21.	22.
23.	

Digestive enzymes are frequently used to:

1.
2.
3.
4.
5.
6.

Digestive enzymes are primarily secreted from:

1.
2.

Discuss which enzymes are necessary for digesting proteins into amino acids.

Discuss which enzymes are necessary for digesting carbohydrates into monosaccharides.

Discuss which enzymes are necessary for lipolysis.

What is pancreatin? What does it do?

Why do athletes generally take digestive enzymes? Is there any research to support this practice?

Compare the antiinflammatory effects of digestive enzymes to that of NSAIDs.

Outline a digestive enzyme supplementation regime for:

1. Nutrient utilization and general use:
2. Pancreatin:
3. Alpha-galactosidase:
4. Bromelain:
5. Lactase:

Exercise 30: Dimethylaminoethanol

What are some alternative names for dimethylaminoethanol?	
1.	2.
3.	4.
5.	6.
7.	8.

Dimethylaminoethanol is frequently used to ______________, ____________, and ____________________.

When was dimethylaminoethanol first marketed? As what?

DMAE acts as a cholinergic precursor that does what?

What type of dosage is needed to stimulate excitatory responses?

Exercise 31: D-Pinitol

What are some alternative names for D-Pinitol?	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.

D-Pinitol is often supplemented in order to act as a _________, increase ___________, and improve _______________.

What sugar-like compound is similar to D-pinitol?

Explain what dietary sources are rich in D-pinitol.

What does D-pinitol stimulate? What conditions optimize these effects?

How does D-pinitol supplementation affect syndrome X?

What are some additional effects of D-pinitol supplementation?

Outline a supplementation regime for D-pinitol that specifically targets:

1. Glucose disposal:
2. Glycogen resynthesis:

Exercise 32: Ecdysterone

What are some alternative names for ecdysterone?	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	

Ecdysterone is frequently taken in order to:

1.
2.
3.
4.
5.

What is ecdysterone? What is another name for it?

What is phytoecdysteroid? Where does it come from?

Where are extracts of ecdysterone usually obtained?

In 1976, Russian scientists reported that ecdysterone derived from ___________ resulted in what effects in rats? Was there an age difference to these responses?

What form of ecdysterone is most effective, and what age group might receive the most effects?

What happens when ecdysterone is combined with protein in aerobically and anaerobically trained subjects?

What are some of the reported effects of ecdysterone?

Outline a supplementation regime that is for general use or targets protein synthesis.

Exercise 33: Epimedium

Epimedium is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
What are some common uses for Epimedium?	
1.	2.
3.	4.
5.	6.

Why is epimedium categorized as an adaptogenic herb?

What are the most important epimedium extracts?

What are some of the effects of icariin? What does it stimulate? Inhibit?

Discuss the dose dependence of icariin, icaritin, and desmethylicaritin.

What has been suggested to be the best quality epimedium?

Outline a general dosage scheme for epimedium supplementation.

Exercise 34: Essential Amino Acids

What are some alternative names for essential amino acids?	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.

List some of the common reasons for supplementing with essential amino acids:	
1.	2.
3.	4.
5.	6.
7.	8.

List the eight essential amino acids:	
1.	2.
3.	4.
5.	6.
7.	8.

What two additional amino acids are often included as essential?

When are EAAs most important? For what reason?

Describe the effects of EAAs and EAAs plus carbohydrates on protein synthesis.

Are nonessential amino acids important for protein synthesis?

Outline a dosage scheme for EAA supplementation that is designed to stimulate protein synthesis and enhance exercise recovery.

Exercise 35: Eurycoma

What are some alternative names for eurycoma?	
1.	2.
3.	4.
5.	6.

What are four common reasons for using eurycoma?

1.
2.
3.
4.

What is eurycoma, and what has it traditionally been used for?

Explain the effects of using eurycoma as a supplement in rodents.

What does the current research suggest about human use of eurycoma?

Outline a general supplementation regime for eurycoma.

Exercise 36: Flaxseed

Flaxseed is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	

Flaxseed is often taken to ____________________, as an ______________, for ____________, and to ____________.

Flaxseed is the richest natural resource of:

1.

2.

The fatty oils from flaxseed contain ____________ linolenic acid esters.

What two fatty acids are found in flaxseed?

What is SDG? How much is found in flaxseed?

What has flaxseed been shown to do?

1.

2.

3.

What happens to total testosterone in response to flaxseed supplementation?

Is flaxseed better for men or women?

Describe a general use supplementation regime for flaxseed.

Exercise 37: Gamma-Aminobutyric-Acid

Gamma-aminobutyric-acid is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	

List some common reasons for using GABA:

1.

2.

3.

4.

What is GABA? What is it formed from?

Where in the body is GABA in the highest concentrations?

What is the growth hormone response to GABA? Is this a dosage-dependent response?

Why would you want to coadminister GABA with phosphatidylserine, phosphatidylcholine, and phosphatidylinositol? Is this effective?

Outline a GABA supplementation regime that targets:

1. Growth hormone release:

2. Blood pressure reduction:

Exercise 38: Ginger

Ginger is also known as:	
1.	2.
3.	4.
5.	6.
7.	

Some common reasons for using ginger are:	
1.	2.
3.	4.
5.	

Ginger is often given in order to ____________________ and ________________.

What is a major reason for using ginger? (Hint: a study done in Germany)

How do the effects of ginger compare with those of aspirin?

What key things related to inflammation are suppressed by ginger?

Outline a supplementation regime for ginger.

Exercise 39: Ginseng

Ginseng is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	14.
15.	16.
17.	18.
19.	20.
21.	22.
23.	24.
25.	26.
27.	28.
29.	30.
31.	32.
33.	34.
35.	36.
37.	38.
39.	40.

Ginseng is frequently taken in order to:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	

What are the two most common forms of ginseng? What is present in high concentrations in these compounds?

1.

2.

What are some effects noted with ginseng supplementation? Are these effects ginseng-species specific?

When should ginseng be taken if attempting to reduce blood glucose?

The ratio of which two compounds is strongly related to the glycemic effects of ginseng?

Outline a ginseng supplementation regime that is designed to affect:

1. Performance:
2. Glucose disposal:

Exercise 40: Glucosamine

What are five alternative names for glucosamine?	
1.	2.
3.	4.
5.	

What are four common reasons for taking glucosamine?

1.
2.
3.
4.

What is glucosamine?

What is glucosamine found as in the body? What two compounds form this?

Glucosamine is found in the greatest concentration in _______________.

Glucosamine is essential for forming _____________ and proteoglycans.

What are proteoglycans? What do they do?

Why is glucosamine popular as a preventative treatment against overuse and degenerative joint diseases?

Summarize the current data about glucosamine's ability to affect overuse and degenerative joint diseases.

Why has it been suggested to combine glucosamine and sulfate?

How effective is glucosamine sulfate at improving symptoms of joint pain, etc.?

Compare glucosamine sulfate with glucosamine hydrochloride.

How does glucosamine supplementation affect glucose levels?

Outline a glucosamine supplementation regime designed to help with joint health.

Exercise 41: Glutamic Acid/Glutamate

Glutamic acid or glutamate is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.

What are five common reasons for taking glutamic acid or glutamate?	
1.	2.
3.	4.
5.	

Animal protein contains _______ glutamate, whereas some plants contain as much as ___________ glutamate.

In which three human organs is glutamate found in high concentrations?

The daily turnover for glutamate in humans is _____.

What is the average stored amount of glutamate in the body?

During rest and exercise, where is glutamate taken up?

Glutamate is important in two specific processes; what are they?

1.

2.

Why is glutamic acid one of the three most prevalent free amino acids in breast milk?

Summarize the effects of supplementing with glutamate or glutamic acid.

Exercise 42: Glutamine

Glutamine is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.

What are some common reasons for using glutamine?	
1.	2.
3.	4.
5.	6.
7.	

Glutamine is the most prevalent free amino acid in the _________ and one of the most prevalent in ____________.

What has the scientific literature suggested about the ergogenic potential of glutamine?

What is the effect of glutamine on glycogen synthesis?

How effective is glutamine at maintaining immune function?

Outline a glutamine supplementation regime that targets:

1. Glycogen resynthesis:
2. General use:

Exercise 43: Glycerol

What are some alternative names for glycerol?	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	

What are some common reasons for using glycerol as a dietary supplement?	
1.	2.
3.	4.
5.	

Glycerol is produced when ______________, __________, ________, and other sugar alcohols are broken down.

Glycerol is the structural backbone for _____________ and _______________.

What is glycerol's effect on blood glucose and insulin?

Does glycerol have any ergogenic effects? Is this supported in the literature?

Outline a glycerol supplementation regime.

Exercise 44: Ipriflavone

Iprivalone is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.

Iprivalone is frequently taken in order to:	
1.	2.
3.	4.

What is ipriflavone?

What is ipriflavone believed to do? Does it do this?

Ipriflavone seems to do what to estrogen when basal levels are low?

Is there a relationship between ipriflavone and bone density? Fracture risk? Is this population-specific?

Does ipriflavone supplementation affect the dosage of estrogen replacement therapies taken by women?

Does ipriflavone enhance the effects of vitamin K and calcium on bone? Why?

Does ipriflavone have any antiinflammatory effects? Through what mechanism?

Generally, what could be an ipriflavone supplementation regime?

Exercise 45: Leucine

Leucine is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.

What are some common reasons for taking leucine?	
1.	2.
3.	4.
5.	6.

Leucine is classified as an ____________ and __________ amino acid.

Leucine is likely the most ________ and _________ amino acid of all.

What two things does leucine seem to affect?

1.

2.

Are the result of leucine supplementation dosage dependent? What is the lowest dose that elicits effects?

What happens to the effectiveness of leucine supplementation when it is administered with carbohydrates and protein?

What is the effect of leucine supplementation on insulin?

Describe the anabolic signal through which leucine operates.

What are the effects of coadministering leucine with glutamine?

Outline a leucine supplementation protocol that is designed to increase protein synthesis.

Exercise 46: N-Acetylcysteine

List some alternative names for *N*-acetylcysteine:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	

What are some common reasons for taking *N*-acetylcysteine?	
1.	2.
3.	4.
5.	6.
7.	8.
9.	

What is *N*-acetylcysteine used to treat?

How does *N*-acetylcysteine promote glutathione availability?

In detail, explain what happens with *N*-acetylcysteine when taken orally (hint: know the steps).

How much of *N*-acetylcysteine is absorbed? How much enters the blood stream?

How much NAC goes toward building peptide bonds, and increasing tissue availability?

Is the NAC-induced increase in intracellular cysteine, hepatic GSH, and whole-body free-radical scavenging ability dose dependent?

How does VO_2 peak relate to NAC response?

Which type of muscles experience greater increases in GSH in response to NAC? (Hint: fast versus slow)

How might NAC relate to EPO?

Outline an *N*-acetylcysteine supplementation regime for:

1. Endurance performance:
2. Antioxidant or general use:

Exercise 47: Ornithine-Alpha-Ketoglutarate

Ornithine-alpha-ketoglutarate is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.

What are some common reasons for taking ornithine-alpha-ketoglutarate?	
1.	2.
3.	4.
5.	6.
7.	8.

What two molecules are combined to make ornithine-alpha-ketoglutarate?

In France, OKG has been used to treat what?

Discuss the effects of OKG?

Explain one of the mechanisms by which OKG is supposed to exert its anabolic and anticatabolic effects. How does this relate to insulin secretion?

Is it equally effective to consume ornithine and/or αKG compared with OKG?

How does OKG compare with glutamine?

Explain what might be entailed in an OKG supplementation regime.

Exercise 48: Phosphatidylserine

Phosphatidylserine is also known as _______ or ______________.

What are some common reasons for consuming phosphatidylserine?	
1.	2.
3.	4.
5.	6.
7.	

Phosphatidylserine is the major phospholipid of ____________.

Where is PS synthesized?

After PS is synthesized, it has what two possible fates:

1.

2.

It is believed that PS might participate in a variety of signal transduction activities. What are some examples of these?

What happens if GABA and PS are coadministered?

What does PS do in regard to glucose concentrations?

What does PS do to ACTH and cortisol?

Should you consume PS before exercise?

Outline a PS supplementation regime.

Exercise 49: Rhodiola

List some alternative names for rhodiola:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	14.
15.	

Rhodiola is used for:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	

In 1968, Soviet pharmacologists suggested that rhodiola meets the criteria to be classified as an ____________.

Rhodiola has been shown to have a wide variety of benefits including:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.

In a clinical trial, 200 mg of *R. rosea* given acutely resulted in:

1. Time to exhaustion =
2. VO_2 peak =
3. VCO_2 peak =

What are the three cinnamyl-D-glycosides found in *R. rosea*?

1.
2.
3.

R. rosea is not present in:

1.
2.
3.
4.

What does the literature suggest about Rhodiola supplementation?

Outline a Rhodiola supplementation regime for:

1. Chronic general use:
2. Acute general use:

Exercise 50: Ribose

Ribose is also known as:	
1.	2.
3.	4.
5.	6.
7.	

List some common uses for ribose:	
1.	2.
3.	4.
5.	6.
7.	

What happens to the creatine kinase system during high-intensity exercise?

What is IMP used for?

IMP can be reduced into what? What happens to these components? Causing what?

How are intramuscular nucleotides resynthesized?

What is phosphoribosyl pyrophosphate?

What does ribose supplementation do to ATP synthesis rates?

Are there any ergogenic effects of ribose supplementation that are manifested as performance increases?

Exercise 51: Sodium Bicarbonate

Sodium Bicarbonate is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.

Some common uses for sodium bicarbonate are:	
1.	2.
3.	4.
5.	6.

What happens to intracellular pH during high-intensity exercise? Why does this happen, and what is the result of this occurrence?

What are some of the effects that have been attributed to sodium bicarbonate supplementation?

1.

2.

3.

When should sodium bicarbonate be administered in order to elicit ergogenic effects?

Why might potassium bicarbonate offer a greater ergogenic effect than sodium bicarbonate?

Outline a sodium bicarbonate supplementation regime.

Exercise 52: Taurine

Some alternate names for taurine are:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	

Taurine is frequently used to _________, as an _________ agent, as an _____________, and to ________________.

Why is taurine uncharacteristic of other amino acids?

Taurine is synthesized from ____________ and _____________.

Taurine's synthesis is dependent on the availability of what compound? What vitamin is this related to?

List four things that have been shown to decrease whole-body taurine levels:

1.

2.

3.

4.

What dramatically increases taurine transport? What dramatically decreases it?

What six vital functions is taurine responsible for?

1.

2.

3.

4.

5.

6.

Low taurine levels in infants can result in what?

What are some clinical conditions that taurine has been shown to affect?

1.

2.

3.

What is taurine's relationship to oxidative stress?

Which fiber type experiences the greatest reductions in taurine as a result of exhaustive exercise?

What is the effect of beta-alanine on intramuscular stores of taurine?

Discuss the effects of taurine on white blood cell DNA.

Discuss the effects of Duchenne muscular dystrophy, and what taurine supplementation can do.

What are the effects of taurine on:

1. Oxidative stress:
2. Glutathione activity:
3. Pancreatic beta-cell function:
4. Glucose utilization:

Outline a taurine supplementation regime.

Exercise 53: Tribulus

Tribulus is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	14.
Tribulus is frequently used to:	
1.	2.
3.	4.
5.	

What is tribulus?

Why have bodybuilders classically used tribulus?

1.
2.
3.

What have scientific studies that have examined tribulus supplementation in animal models concluded? Are results dose dependent?

Discuss the hypoglycemic effects of tribulus and what this results in.

What are the effects of tribulus on COX-2 and/or ACE? What does this result in?

Which type of tribulus has the highest concentrations of steroidal saponins and protodioscin content?

What are some of the active ingredients in *Tribulus terrestris*?

1.

2.

3.

4.

5.

6.

Outline a tribulus supplementation protocol.

Exercise 54: Tyrosine

Tyrosine is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.

Tyrosine is frequently used to:	
1.	2.
3.	4.
5.	6.

What is tyrosine, and where and how is it produced?

Tyrosine is a precursor for what thyroid hormone?

What is tyrosine's primary role in the body? What are the ramifications of this?

What are the documented effects of tyrosine? Is it an ergogenic supplement?

Outline a tyrosine supplementation regime for:

1. Exercise performance and mental acuity:
2. General use:

Exercise 55: Vandium

Vandium is also known as:	
1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	14.

Some common uses for vanadium are:	
1.	2.
3.	4.

In 1985, what major effects of vanadium supplementation were noted?

The use of organic salts or other synthetic compounds has been shown to do what in regard to insulin resistance and hyperglycemia in diabetics?

Discuss the ergogenic effects associated with administering vanadyl sulfate to diabetics.

Are the effects associated with vanadyl sulfate different in healthy individuals compared with individuals with diabetes?

What are some possible side effects associated with vanadyl sulfate supplementation?

Outline a vanadium supplementation regime.

Review Test

1. HMB is made from the combination of:
   a. Leucine and valine
   b. Leucine and KIC
   c. KIC and glycine
   d. Glutamine and AKG

2. The effect of combining Promilin and glucose on muscle glycogen resynthesis:
   a. Increased
   b. Decreased
   c. No effect

3. Alpha-glycerol phosphoryl choline has been shown to do all of the following except:
   a. Improve cognitive function
   b. Improve reaction time
   c. Decrease ACh concentrations
   d. Increase hGH concentrations

4. AKG should be consumed with glucose at a dosage of 0.28g/kg BW/d while working out.
   a. True
   b. False

5. KIC is a precursor for:
   a. BCKA
   b. EAA
   c. BCAA
   d. HMB

6. All of the following are frequently used to treat erectile dysfunction except:
   a. Arginine
   b. Epimedium
   c. Lipoic acid
   d. *Avena sativa*

7. Citrulline is used as a precursor to:
   a. Nitric oxide
   b. Polyamines
   c. Creatine phosphate
   d. All of the above

8. *Avena sativa* is the Latin name for the common oat.
   a. True
   b. False

9. All of the following are considered effects of banaba except:
   a. Increased glucose uptake in adipocytes
   b. In the presence of insulin, there is an increased uptake of glucose
   c. Banaba affects GLUT4 translocation
   d. Hot water and alcohol forms of banaba are equally effective as supplements

10. Beta-alanine is a component of:
    a. Imidazole dipeptides
    b. Carnosine
    c. Anserine
    d. All of the above

11. All of the following are sources of naturally occurring betaine except:
    a. Shrimp
    b. Chicken
    c. Spinach
    d. Wheat germ

12. HMB has been shown to:
    a. Increase muscular strength during anaerobic training
    b. Decrease lean body mass used in conjunction with aerobic training
    c. Work as a catabolic agent that specifically reduces fat mass
    d. Accelerate muscle tissue degradation

13. All of the following are frequently used as an insulin mimetic except:
    a. Branched-chain amino acids
    b. D-Pinitol
    c. Flaxseed oil
    d. Essential amino acids

14. Which of the following is(are) an example of a branched-chain amino acid?
    a. Leucine
    b. Valine
    c. Histidine
    d. a and c
    e. a and b

15. Carnosine is a naturally occurring leucine dipeptide that is primarily found in type I muscle fibers.
    a. True
    b. False

16. *R. rosea* has been found to promote a wide variety of benefits including:
    a. Acting as an antioxidant
    b. Acting as a depressant
    c. Acting as an anticancer compound
    d. a and b
    e. a and c

17. Sodium bicarbonate has been shown to:
    a. Decrease intracellular pH
    b. Delay recovery associated with intense bouts of exercise
    c. Delay the onset of muscular fatigue
    d. a and b
    e. b and c

18. Tyrosine is a precursor for the pituitary hormone thyramine.
    a. True
    b. False

19. Vandium is also known as VSO5.
    a. True
    b. False

20. The effect of consuming 800 mg/d of chondroitin sulfate on knee joint degeneration:
    a. Increased
    b. Decreased
    c. No effect

Review of Terminology

Acetylcholine		Nonsteroidal Antiinflammatory Drug
Adenosine Diphosphate		Norepinephrine
Adenosine Triphosphate		Oxaloacetate
Aerobic	Diabetic	Papain
Amino Acids	Fibromyalgia	*Passiflora caerulea*
Amylase	Flavonoids	Polyamines
Amylolytic Enzymes	Glucagon	Promilin
Anaerobic	Glycogen	Proinflammatory Cytokines
Anticatabolic	Gonadotropin-Releasing Hormone	Proteolytic Enzymes
Antioxidant	*Griffonia simplicifolia*	Pro-Testosterone
Antioxidant	Homocysteine	Pyridoxine
Arginine-alpha-Ketoglutarate	Hyperglycemia	Secoisolariciresinol Glycoside
Arginine-alpha-Ketoisocaproate	Hypertrophy	Sterols
Aromatase Inhibitor	Hypoglycemia	Testosterone
Aspartate Metabolite	IL-1-beta	
Bioavailability	Insomnia	Thyramine
Bromelain	Insulin Mimetic	TNF-alpha
Catecholamine	Melanin	Trimethylated
Cholinergic	Metabolic Antioxidant	Trypsin
Chymotrypsin	Mimetic	Type I fiber
Citric Acid Cycle	Mitochondria	Type II Diabetics
Cortisol	Monosodium Glutamate	Type II Fiber
Creatine Kinase	Nitric Oxide	Type IIb Fiber
Creatine Phosphate	Nitrogen Retention	

Important Abbreviations

4-OH-Ile	GnRH
5-HTP	GSH
AAKG	HCL
ACE	hGH
ACh	HMB
AD	HMG-CoA
AKG	IGF-1
AKIC	IMP
ALA	KIC
alpha-GPC	KIC
ATCH	LH
ATP	MAO
BCAA	MD
BMOV	MSG
CHO	NAC
CLA	NADPH-d
CNS	NO
CoQ10	NSAID
COX-2	OA
CS	P13K
Cys	PC
DA	PE
DEXA	Pi
DHT	PKA
DMAE	PRO
DNA	PS
DR	REE
EAA	RNA
ERT	SDG
GABA	TCA
GDH	TH
GH	

23
Hormonal Supplements
Legal and Illegal

Objectives:

On the completion of this chapter, you will be able to:

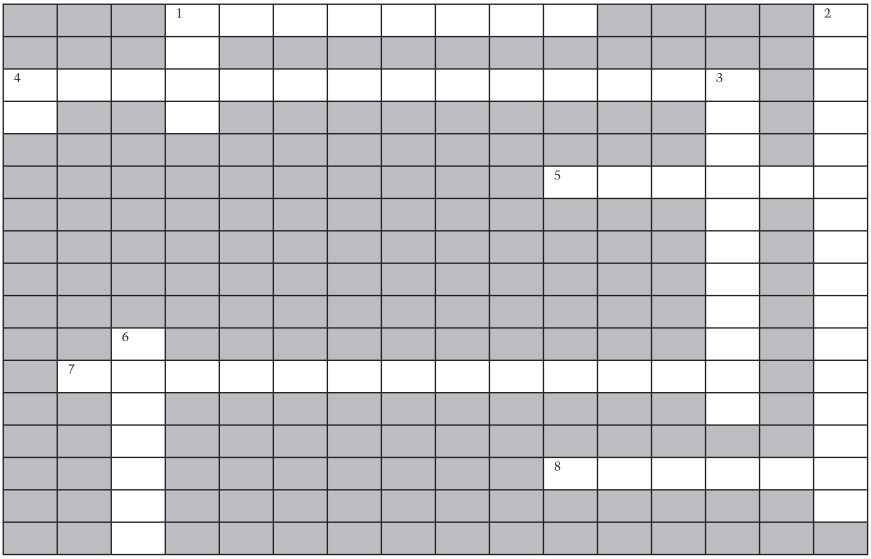
1. Understand the basic types of endogenous hormones and how they are synthesized.
2. Discuss why anabolic-androgenic steroids may be used by athletes.
3. Explain how anabolic-androgenic steroids work.
4. Understand the ramifications of using anabolic androgenic steroids.
5. Differentiate between anabolic-androgenic steroids and prohormones.
6. Discuss the two major prohormones and their effects.
7. Explain the role of the thyroid hormones and why they might be used by athletes.
8. Understand the physiologic effects of using growth hormone.
9. Discuss the physiologic effects of insulin.
10. Explain the clinical uses of a variety of drugs that have been abused by athletes.
11. Understand the ergogenic effects of erythropoietin and discuss the potential contraindications to using this drug.
12. Explain the potential benefits and ramifications of using corticosteroids.
13. Discuss the potential future abuse of gene technologies.

Learning Exercises

Exercise 1: What Is a Hormone?

What is the classic definition of a hormone?

Outline the axis of control, which involves the hypothalamus and pituitary gland.



Across:

1. Hormones that exhibit negative effects are generally
4. Comes from the zona fasciculata and the zona reticularis of the adrenal cortex
5. A class of hormones that are fat soluble
7. A peptide hormone from the peritubular cells of the renal cortex
8. A peptide hormone from the beta cells of the pancreatic islets

Down:

1. A steroid hormone from the zona fasciculata of the adrenal cortex
2. A dipeptide from the follicular cells of the thyroid gland
3. A steroid hormone from the Leydig cells of the testicles
4. Hormones that exhibit positive effects are generally
6. A type of hormone that binds with cell-surface receptors

Describe the different mechanisms of action for: 1) amino acid derivatives, 2) peptide hormones, and 3) lipid derivative (hint: look at Figure 23.2).

Exercise 2: Anabolic Androgenic Steroids

List some of the methods for administering anabolic androgenic steroids:

1.

2.

3.

4.

Discuss some of the medical uses for AASs.

Are AASs useful in healing muscle contusion injury, and immobilization-induced muscle atrophy?

What is a hematologic passport? What does it allow testers to do?

Exercise 3: Anabolic Androgenic Steroids—Chemistry/Physiology

When was testosterone first isolated? From what animal was it isolated?

Where is testosterone primarily secreted from in males?

Small amounts of testosterone are secreted from:

1.

2.

3.

Why would it be important to maximize the anabolic effects and minimize the androgenic effects when developing steroids?

Fill in the following table of frequently used AASs:

Drug name	Method of administration	Anabolic/androgenic activity
Dromostanolone		
Nandrolone esters		
Testosterone esters		
Fluoxymesterone		
Methyltestosterone		
Oxymetholone		
Stanozolol		

What are two frequently used nandrolone esters?

1.

2.

List three frequently used testosterone esters:

1.

2.

Discuss the two main mechanisms of action by which testosterone works:

1.

2.

What enzyme reduces testosterone to 5α-DHT?

Compare the potency of binding DHT to an androgen receptor to testosterone.

What is an androgen-receptor complex? What happens to the androgen-receptor complex?

What are the areas of binding present on the chromosomal DNA termed?

Influencing the transcriptional activity of certain genes can result in androgenic effects, which include:

1.
2.
3.
4.
5.
6.
7.

What is aromatization? What happens to testosterone when it gets aromatized?

What is estradiol capable of stimulating?

Explain what is meant by an anticatabolic effect. If a steroid was termed anticatabolic, what would this mean?

Exercise 4: Anabolic Androgenic Steroids—Effects on Performance

What is meant by "stacking"?

What are the effects of supraphysiologic dosages of AASs on body composition and muscular strength?

Is there an age limit for the effectiveness of AASs?

Exercise 5: Anabolic Androgenic Steroids—Contraindications

The mortality rate for AAS users is _______than nonusers.

AAS users have been shown to:

1.

2.

What are some side effects noted in AAS use?

1.

2.

3.

4.

5.

6.

7.

Exercise 6: Anabolic Androgenic Steroids—Banned/Legality

Name some organizations that have banned AASs:

Under what conditions are AASs legal?

Who regulated anabolic steroids in the 1980s?

What is the Steroid Control Act of 1990?

Exercise 7: Steroid Prohormones

What are prohormones?

What are the two most frequently studied prohormone compounds?

1.

2.

What are some of the effects noted for the two most frequently studied prohormones?

Are there any performance benefits noted from the consumption of either of the two most studied prohormones?

1.

2.

Discuss the side effects that might be associated with the use of prohormones.

Are prohormones banned? Why?

Is it legal to possess prohormones?

Exercise 8: Thyroid Hormones

The thyroid hormones include T3 (____________) and T4 (____________, ____________).

Are there any medical uses for thyroid hormones?

What is hypothyroidism?

The _________ and ____________ have a role in causing the thyroid gland to release T3 and T4.

The ________________ synthesizes and releases ______________ (____), which stimulates the ___________ to release ___________ (_____).

What type of control loop regulates thyroid hormone release?

Where do thyroid hormones originate?

What is thyroglobulin, and what is it composed of?

Which thyroid hormone is the most metabolically active?

Which thyroid hormone is the most prevalent?

What is T3′s role in the body? How is it created?

Is there any evidence that thyroid hormone use can improve exercise performance?

What are some of the effects of thyroid hormones?

What are some of the side effects associated with thyroid hormones?

1.

2.

3.

4.

5.

6.

7.

8.

Are thyroid hormones banned for athletic use? Are they illegal?

Exercise 9: Growth Hormone

What is human growth hormone? Where is it secreted from?

Discuss some of the clinical uses for growth hormone.

Explain how hGH is secreted. In this discussion, explain the factors that stimulate its release and the factors that inhibit its release.

List the factors that have been associated with increased hGH release:

1.
2.
3.
4.

List the factors that have been associated with decreased hGH release:

1.
2.

How is hGH released throughout the day?

In which phase of life is there a gradual decrease in hGH concentrations?

Discuss the two main mechanisms by which hGH affects growth and anabolism.

List three processes that hGH stimulates:

1.
2.
3.

Discuss the effects of using hGH as an ergogenic aid. How does it affect muscle growth, and strength?

What is acromegaly? What are some of its effects?

What are some of the effects of hGH supplementation in older men? Athletes?

Discuss the side effects of using hGH.

Is hGH banned as a sporting supplement? Under what conditions is it legal to have?

Exercise 10: Insulin

What is insulin, and where is it synthesized?

What is insulin's major role in the body?

If blood glucose increases, what happens to insulin release?

How does insulin affect the activity of sodium potassium ATPase?

Define the following terms:

1. Hyperaminoacidemia:
2. Hyperglycemia:
3. Hyperinsulinemia:
4. Hyperinsulinemic clamp:
5 Hypoglycemia:

Discuss some of the symptoms associated with hypoglycemia.

Is insulin use banned for athletes who are not diabetic? Is it illegal to possess or use insulin?

Exercise 11: Insulinlike Growth Factor

What is IGF-1?

What other substance does IGF-1 work with?

The ________ is the primary site of IGF-1 synthesis.

How does IGF-1 exert its anabolic effects?

Discuss the effects of IGF-1 on neuronal structures and functions.

How does IGF-1 relate to cancer?

List some of the claimed anti-aging effects of IGF-1:

1.
2.
3.
4.
5.
6.

Discuss the effects of using IGF-1 in human models. Compare and contrast these results with those seen in animal models.

How effective is oral administration of IGF-1?

What are some of the side effects associated with IGF-1 use?

Is IGF-1 use banned? Is it legal to possess and use?

Exercise 12: Human Chorionic Gonadotrophin

Explain what hCG is. Where is it secreted from?

hCG is structurally similar to ___________ and ____________, which are collectively termed gonadotropins.

What are some clinical uses for hCG?

1. Women:
2. Men:

Why do athlete use hCG?

In pregnant women, where is hCG secreted from? What does this result in?

How does training-induced hCG stimulation affect athletic performance?

What are some of the side effects associated with hCG use?

Is hCG banned? Under what conditions is it legal to use or possess hCG?

Exercise 13: Erythropoietin

What is erythropoietin? Where does it come from? What does it do?

When was EPO first discovered? How is it manufactured today?

Discuss some of the clinical uses of EPO.

Why might an endurance athlete consider using EPO?

Where is EPO synthesized?

Discuss the primary action of EPO. How does it relate to erythroid cell apoptosis?

What are the theories that explain how EPO production is regulated?

How does EPO affect endurance performance? How do these results relate to blood doping?

Using EPO can result in an increased blood _________ as a result of increasing the _________ concentration.

What are some of the major contraindications of using EPO?

Is EPO use banned? Is it legal to possess?

Exercise 14: ACTH and Cortisol

What does ACTH stand for?

Where are ACTH and cortisol produced?

List three names of manufactured cortisol:

1.
2.
3.

Discuss some clinical uses of cortisol.

Which corticosteroid is of greatest importance? Why is it so important?

Discuss how the most important corticosteroid is produced.

What factors stimulate the release of cortisol?

1.
2.
3.
4.
5.
6.

When are cortisol levels the highest?

What are the primary functions of cortisol in the body?

How does cortisol relate to gluconeogenesis?

Are there any physiologic effects of corticosteroid use in regard to athletic performance? Are there any psychologic effects?

What are some of the contraindications of corticosteroid use?

If an athlete abruptly stops using corticosteroids, what happens to insulin?

What is “beta cell burnout”?

Can corticosteroid use cause fluid and electrolyte disturbances?

Is corticosteroid use banned? Is it legal to possess corticosteroids?

Exercise 15: Gene Doping

Define gene doping:

What are some clinical or therapeutic reasons for using gene doping?

Discuss the ramifications of discovering gene mutations.

What is myostatin? What does it do?

List some compounds that might be ideal targets for gene doping. Explain why.

1.

2.

3.

Review Test

1. All of the following are associated with myostatin except:
   a. Myostatin regulates myoblast proliferation
   b. Block myostatin results in continuous muscle cell hyperplasia
   c. Myostatin increases the risk of muscular dystrophy
   d. Currently, MYO-029, a myostatin blocker, is in clinical trials

2. Mechano Growth Factor 1 is an isoform of IGF-1.
   a. True
   b. False

3. A condition termed "empty sella syndrome" can occur as a result of:
   a. Chronic ACTH use
   b. Prolonged cortisol use
   c. a and b
   d. b and c

4. All of the following can result from abruptly stopping corticosteroid use except:
   a. Oversecretion of insulin
   b. The adrenal axis can be disrupted
   c. Hyperglycemia
   d. "Beta cell burnout"

5. What is the effect of low blood sugar on cortisol release?
   a. Increased
   b. Decreased
   c. No effect

6. Using EPO can result in:
   a. Increased erythrocyte concentrations
   b. Improved aerobic exercise performance
   c. Increased risk of intravascular clotting
   d. All of the above

7. The effect of hCG injections on serum testosterone and DHT levels:
   a. Increased
   b. Decreased
   c. No effect

8. All of the following are true about hCG except:
   a. hCG has been used to enhance reproductive technologies
   b. hCG is a glycoprotein secreted by the beta cells
   c. hCG is structurally similar to LH and FSH
   d. hCG appears in maternal blood and is excreted in the urine

9. IGF-1 supplementation is banned by both WADA and the NCAA.
   a. True
   b. False

10. IGF-1 has been shown to preserve nerve cell function and stimulate nerve cell growth.
   a. True
   b. False

11. Insulin-induced hypoglycemia can result in:
   a. Disorientation
   b. Blurred vision
   c. Cessation of sweat response
   d. Seizures

12. Increasing blood glucose levels will result in a(n) ________ in circulating insulin concentrations.
   a. Increase
   b. Decrease
   c. No effect

13. The use of hGH always results in increases in muscular strength and size.
   a. True
   b. False

14. The most potent thyroid hormone is:
   a. T3
   b. Thyroxine
   c. Triiodothyronine
   d. T4
   e. a and c
   f. b and d

15. Hyperthyroidism is marked by:
   a. Cardiac arrhythmia
   b. Increased bowel motility
   c. Menstrual irregularities
   d. All of the above

16. All of the following are true about andro except:
    a. Serum estrogens can become increased
    b. Andro is often classified as an AAS
    c. Andro produces large increases in circulating testosterone
    d. Andro is illegal to possess

17. Some of the side effects associated with AAS use are:
    a. Increased blood pressure
    b. Liver damage
    c. Testicular hypertrophy
    d. a and b
    e. b and c

18. AASs are banned by:
    a. The International Olympic Committee
    b. Major League Baseball
    c. National Collegiate Athletic Association
    d. All of the above

19. Many AAS users practice the technique known as "stacking" or polypharmacy.
    a. True
    b. False

20. All of the following are examples of injectable steroids except:
    a. Testosterone cypionate
    b. Nandrolone decanoate
    c. Methyltestosterone
    d. Dromostanolone

Review of Terminology

Hormones	**AASs: Chemistry**	**AASs: Performance Effects**
Amine	5α-Reductase Enzyme	Androgens
Anabolic	Adrenal Cortex	Polypharmacy
Catabolic	Androgen-Receptor Complex	Stacking
Cortisol	Aromatization	Supraphysiologic
Erythropoietin	Carbon Isotopes	
Growth Hormone	Dihydrotestosterone	**Prohormones**
Hypothalamus	Estradiol	Androstenedione
Insulin	Hormone Response Elements	Dehydroepiandrosterone
Peptide Hormone	Leydig Cells	
Pituitary	Ovaries	**Thyroid Hormones**
Steroid Hormone	Placenta	Hyperthyroidism
Target Tissue	Tetrahydrogestrinone	Hypothyroidism
Thyroxine		Tetraiodothyronine
Triiodothyronine	**Growth Hormone**	Thyroglobulin
	Acromegaly	Thyroid-Stimulating Hormone
Insulin	Adenohypophysis	Thyroxine
Beta cells	Arcuate Nucleus	Triiodothyronine
Cytoplasmic Glucose Transporter	Endogenous	
Hyperaminoacidemia	Exogenous	**Insulinlike Growth Factor**
Hyperglycemia	Ghrelin	Amyotrophic Lateral Sclerosis
Hyperinsulinemia	Glucocorticoids	Somatomedin C
Hyperinsulinemic clamp	Growth Hormone Release Inhibiting Hormone	Trophic
Hypoglycemia	Growth Hormone Releasing Hormone	

Pancreatic Islets	Hypoglycemia	**Human Gonadotrophin**
Polypeptide Chain	Hypothalamic Nuclei	Follicle-Stimulating Hormone
Sodium-Potassium ATPase	Insulin	Glycoprotein
	Periventricular Nucleus	Gonadotropins
	Somatostatin	Hypogonadism
	Somatotrope Cells	Leuteinizing Hormone
		Oocyte
		Trophoblast
Erythropoietin	**ACTH and Cortisol**	**Gene Doping**
Anemia	Adrenocorticotropic Hormone	Mechano Growth Factor
Apoptosis	Beta Cell Burnout	Muscular Dystrophy
Blood Doping	Corticosteroids	Myoblast Proliferation
Erythrocytes	Corticotropin-Releasing Hormone	Myostatin
Erythroid Cells	Dexamethasone	
Glycoprotein	Empty Sella Syndrome	
Hematocrit	Gluconeogenesis	
Hepatocytes	Hydrocortisone	
Hypoxia	Hyperglycemia	
Reticulocytosis	Hypoglycemia	
Thrombosis	Prednisone	

Important Abbreviations

^{12}C	hCG
^{13}C	hGH
AAS	HREs
ACTH	IGF-1
AIDS	IOC
ALS	LH
AMA	LSD
ANDRO	MGF-1
ASCA	MYO-029
CRF	NCAA
DEA	SH
DHEA	T
DHT	T3
EPO	T4
FDA	THG
FSH	TSH
GDF-8	USADA
GHRH	WADA
GHRIH	

Part V
Special Topics

24
Special Legal Review *The Androstenedione Ban and the Criminalization of Steroid Precursors—Implications for the Sports Nutritional Supplement Market*

Objectives

On the completion of this chapter, you will be able to:

1. List the major laws and acts that affect the supplement industry.
2. Discuss in detail the ramification and guidelines presented in the laws and acts that affect the supplement industry.
3. Understand the changes made in 2004 to the 1990 Anabolic Steroid Control Act.
4. Discuss the legal ramifications of possession or distribution of anabolic androgenic steroids.
5. Explain the levels of oversight for the supplement industry.

Learning Exercises

Exercise 1: Background

Fill in the following timeline with the major governmental policy that occurred on the date noted and describe the ramifications of these acts:

1. 1990:
2. 1994:
3. March 11, 2004:
4. October 22, 2004:
5. January 20, 2005:

Exercise 2: Public Health Protections Against Dietary Supplements

Why was the DSHEA law enacted?

How did the DSHEA provide legitimate protection for the public?

What is the FDCA?

What are the penalties for introducing adulterated products into interstate commerce?

Discuss how dietary supplements can be classified as adulterated.

How was ephedra deemed to be adulterated?

Exercise 3: DSHEA Protections Against Adulterated "New Dietary Ingredients"

What is a new dietary ingredient?

What two criteria allow for a dietary supplement to not be classified as adulterated?

1.

2.

What actions must a supplement company and distributors take when introducing a new dietary ingredient that has not previously been present in the food supply?

What information must be included when introducing a new ingredient?

1.

2.
a.
b.
c.

How are reasonable expectations of safety determined?

Exercise 4: Food and Drug Administration's Action Against Androstenedione

When was androstenedione first introduced?

What is androstenedione?

List some of the potential effects that were promoted as being stimulated by androstenedione:

1.

2.

3.

Is androstenedione an adulterated new dietary ingredient?

What is meant by the FDA's terminology of "lawfully marketed"?

Is androstenedione present in the food supply without chemical modification? Explain.

Is it possible to demonstrate a reasonable expectation of safety when using androstenedione?

Why is it important to discuss efficacy when considering androstenedione supplements?

Exercise 5: The New Anabolic Steroid Control Act

In 1980, what governing body regulated anabolic steroids?

When was anabolic steroid use banned by the IOC?

What organizations recommended against scheduling steroids as a controlled substance? Why did they make such a recommendation?

What are some of the specifics of the 1990 Anabolic Steroid Control Act?

1. Drugs/compounds included:
2. Schedule III:
3. Possession:
4. Distribution:

What was a secondary effect of the ASCA? How did it affect the dietary supplement industry?

Why was new legislation passed in October 2004?

What are some of the provisions of the Anabolic Steroid Act of 2004? Explain.

1. Education:
2. New additions or drugs/compounds classified as anabolic steroids:
3. What was removed from the wording of the original 1990 act?

Why is it ironic that under the new law a compound does not need to be anabolic to be illegal? What constitutes a compound's illegal status?

Exercise 6: Ramifications for the Nutrition Industry

Describe the bill being presented by Senator Richard Durbin of Illinois.

What has been proposed by the Institute of Medicine of the National Academies?

How has the media hurt the supplement industry?

What is a practice or change that the FDA could make that would improve its management of dietary supplement issues?

Review Test

1. The Steroid Control Act of 2004 includes _____ in its list of banned substances.
   a. Creatine monohydrate
   b. Dehydroepiandrosterone
   c. Androstenediol
   d. Hydroxyl-methyl-butyrate

2. The drug made famous by the BALCO scandal is:
   a. THG
   b. Methyldienolone
   c. Tetrahydrogestrinone
   d. a and b
   e. a and c
   f. b and c

3. The phrase "promotes muscle growth" was added to the 1990 steroid act when it was revised in 2004.
   a. True
   b. False

4. In 1990, the ASCA classified anabolic steroids as a:
   a. Schedule III drug
   b. Schedule I drug
   c. Schedule IV drug
   d. None of the above

5. Which organization recommended that anabolic steroids be scheduled in 1990 because of the many physical and psychologic dependency issues associated with their use?
   a. AMA
   b. FDA
   c. DEA
   d. None of the above

6. In what year did the International Olympic Committee ban steroid use?
   a. 2004
   b. 1990
   c. 1988
   d. 1975

7. In what year was Ben Johnson's doping violation in the Olympics?
   a. 2004
   b. 1990
   c. 1988
   d. 1975

8. Under the ASCA, distributing steroids can result in:
   a. $1000 fine for the first offense
   b. A 5-year prison term for the first offense
   c. A $250,00 fine for the first offense
   d. a and b
   e. b and c

9. Androstenedione was classified as adulterated by the FDA because there was no evidence that it was ever lawfully marketed as a dietary ingredient before 1998.
   a. True
   b. False

10. One exemption to being deemed adulterated is to present evidence that the compound was present in the food supply in a form that was not chemically altered.
    a. True
    b. False

11. A new dietary ingredient is defined as a compound that was not marketed in the United States before October 15, 1994.
    a. True
    b. False

12. How many days before a product is introduced to interstate commerce does a company need to submit evidence that the compound has a history or evidence of safety?
    a. 100
    b. 75
    c. 50
    d. 25

13. The secretary of Health and Human Services has the power to declare a supplement an "imminent hazard" to public health or safety and thus cease its sales.
    a. True
    b. False

14. What act prohibits the introduction of adulterated products into interstate commerce?
    a. DSHEA
    b. ASCA
    c. FDCA
    d. None of the above

15. What is the penalty for introducing adulterated products into interstate commerce?
    a. $250,000
    b. $1000
    c. $10,000
    d. None of the above

16. In what year was the DSHEA presented and passed by Congress?
    a. 2004
    b. 2000
    c. 1994
    d. 1990

17. What dietary supplement was pronounced as adulterated on March 11, 2004 by the FDA?
    a. Androstenedione
    b. DHEA
    c. Creatine
    d. Glutamine

18. What should be included in a description of a dietary supplement's contents?
    a. History of use or other evidence of safety
    b. Conditions of use stated in the product labeling
    c. Level of the new dietary ingredient present in the product
    d. All of the above
    e. None of the above

19. The media sensationalizes and often has a bias against sports supplements.
    a. True
    b. False

20. To ensure that the supplement industry is successful:
    a. The industry must work within the guidelines set forth in the DSHEA
    b. All media and governmental biases toward supplements must be addressed
    c. The FDA and the supplement industry must find a way to coexist
    d. All of the above

Review of Terminology

Background	**Public Health Protections**	**DSHEA Protections**
Dietary Supplement Health and Eduction Act	Adulterated	New Dietary Ingredient
Food and Drug Administration	The Food, Drug and Cosmetic Act	
ASCA 2004	**Ramifications**	
The Anabolic Steroid Control Act	Center for Food Safety and Applied Nutrition	

Important Abbreviations

ASCA	FDA
CFSAN	FDCA
DSHEA	NDI

25
Very-Low-Carbohydrate Diets

Objectives

On the completion of this chapter you will be able to:

1. Explain the basic metabolism of ketone bodies.
2. Describe the different ketone bodies and how they are synthesized.
3. Relate ketone body production to very-low-carbohydrate "ketogenic" diets (VLCKDs).
4. Understand the mechanisms used to regulate ketone body synthesis and utilization.
5. Explain the different metabolic adaptations that occur in response to VLCKDs.
6. Compare and contrast weight loss and body-composition changes in VLCKDs with low-fat diets.
7. Describe why many individuals believe VLCKDs increase cardiovascular disease risk and refute these claims.
8. Understand the effects of VLCKDs on total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triacylglycerols.
9. Describe the effects of VLCKDs on markers of inflammation.
10. Relate VLCKDs to exercise performance and weight loss.

Learning Exercises

Exercise 1: Ketone Metabolism

List three areas of investigation into clinical conditions in regard to ketones:

1.

2.

3.

During fasting or dietary carbohydrate restriction, what happens to whole-body metabolism?

When there are high rates of triacylglycerol lipolysis, there is an accumulation of ____________ and the formation of ______________.

What are the three ketones that can be formed from lipid metabolism?

1.

2.

3.

Ketones are synthesized in the ________from __________derived from fatty acid oxidation.

An increase in ketone levels is indicative of what?

List three responses that the body undergoes during a very-low-carbohydrate ketogenic diet.

1.

2.

3.

Explain how ketone bodies can be converted to fuel. What are they converted to?

Fill in the following in regard to ketones:

1. Healthy individual (fed state) = ________ mmol/L
2. Healthy individual (fasted state) = ________ mmol/L
3. 20 days of fasting = ________ mmol/L
4. Healthy men (isocaloric VLCKD, 2 weeks) = ________ mmol/L
5. Healthy men (isocaloric VLCKD, 3 weeks) = ________ mmol/L
6. Uncontrolled diabetes = ________ mmol/L

Exercise 2: Regulation of Ketones

List the three levels of regulation associated with ketogenesis. Which one is extrahepatic?

1.
2.
3.

What are the three enzymes that regulate the levels of regulation listed above?

1.
2.
3.

The amount of __________ that passes through the liver determines the extent of hepatic ketogenesis.

The rate of lipolysis at the adipocytes determines the amount of ____ _____ delivered to the liver.

How is the rate of adipose tissue metabolism influenced by insulin?

What does insulin do?

1. To cAMP levels:
2. To HSL activity:
3. To glucose uptake of adipocytes:
4. To fatty acid synthesis:

Place the following items in order:

1. ________: Fatty acids in the mitochondria are oxidized
2. ________: Fatty acid levels are increased as a result of triacylglycerol hydrolysis
3. ________: Fatty acids are esterified into TG or taken into the mitochondria

What are two fates for fatty acids in the liver?

1.

2.

What happens to fatty acids once they are in the mitochondrial matrix? What do they form?

__________ activates long-chain fatty acids in the presence of CoA and ATP.

Acylcarnitine is formed from _________ and ___________.

What role does acylcarnitine have?

Explain what happens to acylcarnitine once it is within the mitochondrial matrix.

Insulin causes an up-regulation of malonyl-CoA, which inhibits _______________.

Explain what happens when carbohydrates are readily available in regard to malonyl-CoA and fatty acid oxidation.

What two pathways are acetyl-CoA molecules portioned between?

1.

2.

As the level of fatty acids increases, which pathway is acetyl-CoA preferentially portioned toward?

Why is HMG-CoA important in the regulation of ketone metabolism?

Exercise 3: Utilization of Ketones

What role do ketones have during starvation or a VLCKD?

Why does skeletal muscle contribute a large portion to the available ketone body consumption?

List the three enzymes involved in ketone oxidation, and give the basic reaction that they stimulate.

1. ________________________:
2. ________________________:
3. ________________________:

The levels of ketone bodies in the plasma are directly proportional to the __________________.

Exercise 4: Metabolic Adaptations

Fill in the table below with 10 adaptations to fat metabolism related to low-carbohydrate/high-fat diets:		
	⇑⇓	Response
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
Fill in the table below with 10 adaptations to carbohydrate metabolism related to low-carbohydrate/high-fat diets:		
	⇑⇓	Response
1.		
2.		
3.		
4.		
5.		
6.		
	⇑⇓	Response
7.		
8.		
9.		
10.		

What occurs when muscle glycogen stores are lowered and a VLCKD is consumed?

What happens to muscle glycogen levels when a high-fat/low-carbohydrate diet is consumed for >7 days?

List the sources of increased fat oxidation:

1.

2.

3.

Explain what happens when carbohydrate loading occurs after a period of consuming a VLCKD (>7 days).

Why does it take several weeks to switch over to optimal fat utilization?

Exercise 5: Weight Loss

List two modifiable factors that can have a major impact on energy balance:

1.

2.

What is the major premise behind weight loss in regard to diet modification?

Compare 3–6 months of a VLCKD to that of a LF diet. Which stimulates more weight loss? (Hint: see Figure 25.3)

Discuss the possible reasons for weight loss associated with a VLCKD.

Explain the first law of thermodynamics.

Explain the second law of thermodynamics.

Discuss the rationale for the fact that a "calorie may not be a calorie."

Exercise 6: Body Composition

What is the common criticism of VLCKDs?

Do VLCKDs result in a preferential loss in lean body mass or fat mass?

VLCKD may preferentially decrease body fat in the trunk region. Why might this be significant?

What is considered to be a reason for the increased fat loss on a VLCKD?

Exercise 7: Cardiovascular Disease Risk

What is atherosclerotic disease?

What does C-reactive protein levels predict?

How do VLCKDs relate to cardiovascular disease?

Exercise 8: Metabolic Syndrome

What is metabolic syndrome?

List the seven key features of metabolic syndrome:

1.
2.
3.
4.
5.
6.
7.

How many adults have metabolic syndrome?

1. >20 years of age:
2. >40 years of age:

What are the basic therapies implemented in the treatment of metabolic syndrome?

Fill in the following table with characteristics of metabolic syndrome:		
Factor	Men	Women
TAG (mg/dL)		
HDL-C (mg/dL)		
Fasting glucose (mg/dL)		
Waist circumference (cm)		
Systolic blood pressure (mm Hg)		

Exercise 9: Total Cholesterol

What two factors have strong relationships with the severity of coronary heart disease and the occurrence of coronary artery disease?

1.
2.

Discuss the effects of a VLCKD on total cholesterol.

How does weight loss or gain relate to changes in total cholesterol?

Discuss the effects of VLCKDs, which are rich in either polyunsaturated or monounsaturated fat, on total cholesterol.

Exercise 10: Low- and High-Density Lipoprotein Cholesterol

How do HDL-C and LDL-C relate to CAD?

1. HDL-C:
2. LDL-C:

An HDL-C value of ________ mg/dL is considered to be a factor that attenuates the risk for CAD.

What happens to HDL-C, LDL-C, and the TC/HDL-C in response to a VLCKD?

1. HDL-C:
2. LDL-C:
3. TC/HDL-C:

How do women and men compare in their HDL-C and LDL-C responses to a VLCKD?

Exercise 11: Fasting Triacylglycerols

Discuss the relationship between fasting TAGs and cardiovascular disease.

What is the effect of a VLCKD on TAGs?

Under what conditions were the highest reductions in TAGs stimulated?

Exercise 12: Postprandial Lipemia

What is the relationship between TAG-rich lipoproteins and CAD?

Discuss the effects of VLCKD on postprandial lipemia. What stimulates these effects?

What happens to the hepatic LDL-TAG production rates in response to a carbohydrate-rich diet?

What happens to the hepatic LDL-TAG production rates in response to a VLCKD?

Exercise 13: Low-Density Lipoprotein Subclass Distribution

In most incidences, the increases in LDL-C associated with VLCKDs would be considered a negative response. What alteration to LDL-C might offset this?

What are pattern A and B LDLs? How do these relate to CAD?

Discuss the effect of switching from a high-fat diet to a low-fat diet on LDL particles. How does this relate to TAG?

What are the effects of reducing carbohydrates on TAG, HDL-C, and LDL particles?

What happens to the pattern of LDL when switching to a VLCKD?

Exercise 14: Inflammatory Markers

What does the inflammatory process have a major role in? Why?

What do the primary proinflammatory cytokines and oxidatively modified LDL do? How do they relate to cardiovascular disease?

What are the effects of a 4-week VLCKD in normal-weight men on:

1. C-reactive protein:
2. IL-6:
3. TNF-α:

What are the effects of a 6-week VLCKD in overweight men on:

1. hs-CRP:
2. TNF-α:
3. IL-6:
4. sICAM:

Exercise 15: Practical Applications

Describe why VLCKDs have not traditionally been accepted by sports nutritionists.

Generally, VLCKDs have been shown to ____________ performance. What might be a reason for this?

From a historical perspective, describe the effects of a VLCKD.

Summarize the effects of a VLCKD on

1. Submaximal endurance performance:
2. High-intensity performance:

Review Test

1. VLCKDs seem to inhibit submaximal exercise capacity, but do not affect high-intensity exercise performance.
   a. True
   b. False

2. All of the following are ketones except:
   a. Acetate
   b. Acetoacetate
   c. α-Hydroxybutyrate
   d. β-Hydroxybutyrate

3. Ketone body production indicates:
   a. An increase in lipogenesis
   b. An accelerated rate of ketogenesis
   c. An increase in β-oxidation
   d. a and b
   e. b and c

4. Ketones can be converted to acetyl-CoA, which can then be used as a fuel substrate.
   a. True
   b. False

5. The blood ketone concentration of a healthy fed adult would be ~___________ mmol/L.
   a. 0.3
   b. 10
   c. 2
   d. 0.1

6. Ketogenesis is controlled at three levels. Which is extrahepatic?
   a. TAG hydrolysis at the adipocytes
   b. The amount of free fatty acid transport across the inner mitochondrial membrane
   c. The partitioning of acetyl-CoA between the oxidative and ketogenic pathways
   d. None of the above occur in the extrahepatic areas

7. The portioning of acetyl-CoA between the oxidative and ketogenic pathways is controlled by:
   a. Hormone sensitive lipase
   b. Carnitine palmitoyl transferase
   c. Mitochondrial HMG-CoA synthase
   d. None of the above

8. "Physiologic ketosis" is considered to be more extreme than diabetic hyperketosis.
   a. True
   b. False

9. HMG-CoA synthase mRNA and protein levels are increased:
   a. When insulin is injected
   b. During diabetes
   c. Under conditions of starvation
   d. a and b
   e. b and c

10. When insulin concentrations are increased:
    a. Malonyl-CoA is activated
    b. An increase in fatty acid oxidation occurs
    c. TAG hydrolysis is stimulated
    d. There is an enhanced delivery of fatty acids to the liver

11. All of the following are enzymes involved in ketone oxidation except:
    a. Succinyl CoA-oxoacid transferase
    b. β-Hydroxybutyrate dehydrogenase
    c. Methylacetoacetyl-CoA thiolase
    d. Hormone sensitive lipase

12. All of the following are increased by VLCKDs except:
    a. Gluconeogenesis
    b. Muscle glycogen utilization rate
    c. Fat oxidation
    d. Muscle lipoprotein lipase

13. The effect of a VLCKD on carbohydrate oxidation:
    a. Increased
    b. Decreased
    c. No effect

14. The effect of a VLCKD on phosphoenolpyruvate carboxykinase:
    a. Increased
    b. Decreased
    c. No effect

15. Increased fat oxidation seems to result from:
    a. Increased circulation of fatty acids
    b. Increased availability of ketones
    c. Decreased skeletal muscle lipoprotein lipase activity
    d. a and b
    e. b and c

16. VLCKDs have been shown to stimulate less weight loss than low-fat diets.
    a. True
    b. False

17. The first law of thermodynamics suggests that the form of energy must change and the total is always the same.
    a. True
    b. False

18. The effect of VLCKDs on fat loss:
    a. Increased
    b. Decreased
    c. No effect

19. Some key features of metabolic syndrome include:
    a. Insulin resistance
    b. Central obesity
    c. Hypertension
    d. All of the above
    e. None of the above

20. If an individual has metabolic syndrome, you might expect to see:
    a. Fasting TAG levels <150 mg/dL
    b. HDL-C >50 mg/dL
    c. Fasting glucose levels >120 mg/dL
    d. Systolic blood pressure <130 mm Hg

Review of Terminology

Ketone Metabolism	**Regulation of Ketone Production**	**Utilization of Ketones**
Acetoacetate	3-Hydroxy-3-methylglutayl-Coenzyme A	β-Hydroxybutyrate Dehydrogenase
Acetone	Acetyl-CoA	Methylacetoacetyl-CoA Thiolase
Acetyl-CoA	Acylcarnitine	Succinyl CoA-oxoacid transferase
β-Hydroxybutyrate	Acyl-CoA Synthetase	
Diabetic Hyperketoacidosis	Carnitine	**Cardiovascular Disease**
Isocaloric Physiologic Ketosis	Carnitine Palmitoyl Transferase-1	Atherosclerotic
Ketogenesis	Citrate Synthase	C-Reactive Protein
Ketone Bodies	Extrahepatic	
Lipolysis	Hormone Sensitive Lipase	**Metabolic Syndrome**
Triacylglycerol	Malonyl-CoA	Dyslipidemia
	Mitochondria	Fibrinolysis
Total Cholesterol	Mitochondrial HMG-CoA	Hypertension
Coronary Artery Disease	Oxidation	Procoagulation
Coronary Atherosclerosis		
Low-Density Lipoprotein	**Postprandial Lipemia**	**LDL Subclasses**
Monounsaturated Fat	Atherogenicity	Atherogenic
Polyunsaturated Fat	Lipemia	Pattern A
	Postprandial	Pattern B
Inflammatory Markers		
Atheroma		
Cellular Adhesion Molecules		
Leukocyte		
Normolipidemic		
Oxidatively Modified LDL		
Pathogenesis		

Important Abbreviations

ATP	LF
cAMP	oxLDL
CAMs	SCOT
CoA	sICAM-1
CPT-1	TAG
CPT-11	TC/HDL-C
HDL-C	TCA
HMG-CoA	TG
hs-CRP	TNF-α
HSL	VLCKD
IL-6	VLDL-TAG
LDL-C	

26
Eating to Improve Body Composition

Objectives

On the completion of this chapter, you will be able to:

1. Understand the scientific literature about the effectiveness of various dietary strategies that have been used for weight loss.
2. Explain specific details about various studies that have investigated specific dietary practices.
3. Discuss the concept of metabolic advantage and how it relates to different dietary practices.
4. Understand the concept of metabolic advantage and the components that contribute to it.
5. Explain the effects of nutrient-timing practices and how they relate to training adaptations and or physiologic changes.
6. Discuss the concept of meal frequency and how this may impact weight loss or gain.
7. Understand the effects of coupling protein supplements with resistance training on physiologic adaptations.
8. Differentiate the physiologic adaptations associated with soy, casein, and whey protein supplements.

Learning Exercises

Exercise 1: Background Information

Generally, how is a lean physique obtained?

Are there any situations whereby a large percent of body fat might be advantageous?

How do very-low-carbohydrate (ketogenic) diets compare with high-carbohydrate diets in regard to body mass and body fat loss?

How do low-fat (20%) and moderate-fat (35%) diets compare on:

1. Body weight (kg):
2. BMI (kg/m^2):
3. Waist circumference:

List four things that replacing carbohydrates with protein accomplishes in the short term.

1.
2.
3.
4.

How do high-carbohydrate (68 g protein/day) and high-protein (125 g protein/day) diets compare in the following:

1. Body weight:
2. Fat mass:
3. Lean mass:
4. Serum cholesterol:
5. TAG:
6. Ratio of TAG/HDL:

How do low-carbohydrate (<20 g/day) and low-fat (<30% energy from fat) diets compare in the following:

1. Body weight change (%):
2. Fat mass (kg):
3. Fat-free mass (kg):

Discuss how low-carbohydrate or very-low-carbohydrate diets can result in decreases in body mass and body fat even though they might result in small increases in caloric intake compared with high-carbohydrate diets.

Explain the effects of a very-low-carbohydrate diet on total and regional body composition.

How do low-and high-carbohydrate diets compare in their ability to stimulate weight loss after 6 months and after 12 months?

Exercise 2: Metabolic Advantage

Discuss what is meant by metabolic advantage?

Explain what constitutes a metabolic advantage in low-carbohydrate diets.

What are some of the hormonal changes associated with a low-carbohydrate diet?

1.
2.
3.
4.
5.
6.
7.
8.

Which is favored when using a low-carbohydrate diet, gluconeogenesis or glycolysis?

What is gluconeogenesis? How much energy does it take to make 1 mol of glucose?

List the energy-dependent processes needed to maintain the turnover of body proteins:

1.
2.
3.
4.
5.

What happens to postprandial thermogenesis when consuming a high-protein diet?

Discuss how high-protein diets relate to uncoupling proteins.

What are the effects of hyperinsulinemia on fat mass?

What is glycosuria? How does it relate to weight gain?

Exercise 3: Nutrient Timing

Discuss the effects on protein synthesis of consuming protein immediately after a training bout or when intake is delayed (>1 hour).

How does postexercise supplementation affect body mass?

Exercise 4: Meal Frequency

Discuss the effects of grazing or gorging on weight loss, the thermic effect of food, and 24-hour energy intake.

List some effects of irregular meal patterns:

1.

2.

3.

4.

Discuss the effects of irregular and regular meal patterns on energy intake, weight loss, etc.

Discuss how two meals per day compared with six meals per day affects body mass and lean body mass losses.

Exercise 5: Protein Supplementation and Exercise

List and explain the results of combining protein supplements with exercise on:

1. Exercise + diet + casein:
   a. Percent body fat:
   b. Lean body mass:
   c. Muscular strength:
2. Exercise + diet + whey protein:
   a. Percent body fat:
   b. Lean body mass:
   c. Muscular strength
3. Diet:
   a. Percent body fat:
   b. Lean body mass:
   c. Muscular strength:

How does supplementing the diet with soy or whey protein affect the results of a strength-training program?

What are the effects of consuming up to 2.8 g of protein a day? Is this safe?

Review Test

1. If Janna consumed a whey protein shake ________________ after her high-intensity resistance training bout, she would experience greater gains in lean body mass.
   a. 2 hours
   b. Immediately
   c. 1 hour
   d. 4 hours

2. The effect of hyperinsulinemia on fat mass:
   a. Increased
   b. Decreased
   c. No effect

3. All of the following are associated with consuming protein at the expense of carbohydrates except:
   a. Enhanced glycemic control
   b. Sparing of muscle protein loss
   c. Decreased thermogenesis
   d. Increased satiety

4. High-protein diets tend to have higher intakes of BCAAs, specifically leucine, which:
   a. Increases glucose utilization
   b. Modulates insulin signaling
   c. Inhibits the glucose-alanine cycle
   d. None of the above

5. The effect of a high-protein diet on the ratio of TAG/HDL.
   a. Increased
   b. Decreased
   c. No effect

6. All of the following are true about the low-carbohydrate diets compared with low-fat diets except:
   a. The low-carbohydrate group lost significantly more body weight
   b. The low-carbohydrate group experienced greater decreases in serum triglycerides
   c. The low-fat group lost more lean body mass
   d. The low-fat group lost less fat mass

7. When comparing a 48% carbohydrate diet group with a <10% carbohydrate group, Volek et al. demonstrated that the low-carbohydrate group gained significantly more lean body mass.
   a. True
   b. False

8. Low-carbohydrate diets result in:
   a. Increased levels of glucagons
   b. Activation of phosphoenolpyruvate carboxykinase
   c. Activation of glucose 6-phosphatase
   d. Inhibition of pyruvate kinase
   e. All of the above

9. To synthesize 6 mol of glucose from pyruvate of lactate it would cost ______ mol of ATP.
   a. 6
   b. 12
   c. 24
   d. 36

10. Low-carbohydrate diets result in a decreased turnover of body proteins.
    a. True
    b. False

11. Ketogenic diets result in increased transcription of mitochondrial uncoupling proteins.
    a. True
    b. False

12. All of the following are true about postresistance training protein supplementation except:
    a. Waiting 2 hours after training results in less increase in mean fiber area than consuming the beverage immediately after training
    b. Waiting 2 hours after training results in less insulin release than consuming the beverage immediately after training
    c. Consuming a protein beverage immediately after training stimulates a greater increase in quadriceps femoris muscle size
    d. There is no difference in the glucose response between early and late consumption of protein

13. Consuming 2.8 g of protein per kilogram body mass results in significant impairments in renal function in healthy, well-trained athletes.
    a. True
    b. False

14. The effect of multiple small feedings throughout the day on the thermic effect of feeding.
    a. Increased
    b. Decreased
    c. No effect

15. Irregular meal frequency is associated with a lower fasting:
    a. Total cholesterol
    b. HDL cholesterol
    c. LDL cholesterol
    d. a and b
    e. a and c

16. Casein, when coupled with resistance training, results in greater strength gains compared with whey protein supplementation and resistance training.
    a. True
    b. False

17. The effect of adding soy protein supplements to a resistance-training program on lean body mass gains compared with training only:
    a. Increased
    b. Decreased
    c. No effect

18. All of the following are true about whey protein supplements except:
    a. Whey protein supplementation can increase peak power
    b. Whey protein, when coupled with resistance training, produces greater lean body mass gains than casein
    c. Whey protein supplements can augment antioxidant defenses
    d. Whey protein coupled with resistance training results in greater losses of fat mass

19. Mediterranean-style diets:
    a. Are moderate in fat
    b. Are easier to adhere to
    c. Result in weight loss
    d. None of the above

20. Most sports benefit from lower body-fat content; some sports, such as _________, might benefit from higher body-fat content.
    a. Sumo wrestling
    b. Sprinting
    c. Long-distance, open-water swimming
    d. a and b
    e. a and c

Review of Terminology

Metabolic Advantage	**Meal Frequency**	**Protein Supplementation**
6-Phosphofructo-1-kinase	Gorging	Casein
Cori Cycle	Grazing	Hydrolysate
Free Fatty Acids		Hypertrophic
Fructose 1,6-biphosphatase		Hypocaloric
Glucagon		
Gluconeogenesis		
Glucose 6-phosphatase		
Glycemic Control		
Glycolysis		
Glycosuria		
Hexokinase		
Hyperinsulinemia		
Insulin		
Ketogenic Diets		
Phosphoenolpyruvate Carboxykinase		
Postprandial Thermogenesis		
Pyruvate Kinase		
Thermodynamics		
Triglycerides		
Uncoupling Proteins		

Important Abbreviations

ATP	
AUC	
UCP	

27 Nutrition Before, During, and After Exercise for the Endurance Athlete

Objectives

On the completion of this chapter, you will be able to:

1. Understand the consequences of dehydration.
2. Discuss the mechanisms by which the body regulates body temperature and how this affects dehydration.
3. Explain the role of carbohydrate stores in the body and how they affect exercise performance.
4. Understand the relationship between muscle glycogen and exercise performance.
5. Discuss the effects of endurance exercise on muscle damage, soreness, and immune responses.
6. Define the effects of hyperhydration on performance.
7. Talk about the process of glycogen loading and the effects of this practice on performance.
8. Clarify the role of pre-event carbohydrate feedings and outline the basic guidelines for endurance athletes.
9. Discuss the role of fluid, electrolyte, and carbohydrate supplementation during an endurance bout of exercise.
10. Talk about the relationships among cortisol, carbohydrates, and immunosuppression.
11. Appreciate the value of a postexercise fluid and carbohydrate replacement regime.

Learning Exercises

Exercise 1: Dehydration

Define and explain the following terms:

1. Convection:
2. Conduction:
3. Evaporation:

During exercise, what is the primary method for dissipating heat? What percentage does this account for?

______ kcals of heat are dissipated for every ________ of water that evaporates into the environment from the body.

What is the relationship between the amount of heat generated and the intensity of the exercise being performed?

Explain the process by which heat is transferred from the working muscles to the skin, where it is transferred to the environment.

With increasing sweat rates, there is a decrease in ________, which results in?

1.
2.
3.
4.

Describe the results of the following fluid losses:

1. 1% body-weight loss:
2. 4% body-weight loss:
3. 6% body-weight loss:

When large volumes of sweat are produced, what happens to electrolytes? What is the consequence of this?

Exercise 2: Depletion of Carbohydrate Stores

The human body has limited carbohydrate stores. How does this relate to fatigue?

Muscle stores approximately __________ g of glycogen, whereas the liver stores ~_______ g of glycogen.

What happens to the rate of glycogen usage as the intensity of exercise increases?

Describe the major fuel sources for the following intensities of aerobic exercise:

1. Low intensity (40%–50% VO_2 max):
2. Moderate intensity (60%–75% VO_2 max):
3. High intensity (>75% VO_2 max):

At moderate-intensity exercise, where does the carbohydrate come from?

What happens when blood glucose levels decrease below 3.5 mM?

At high intensities of aerobic exercise, fatigue is directly related to what?

Why is lactic acid produced as a result of higher-intensity exercise?

Does muscle glycogen depletion affect team-sports participants?

Exercise 3: Consequences of Endurance Exercise

Define and explain the relationship of the following to endurance exercise:

1. Muscle damage:
2. Muscle soreness:

List and explain the three major causes of muscle damage:

1.

2.

3.

How does proper nutrition relate to muscle damage?

What types of muscle contractions have the greatest potential to produce muscle damage? What are the consequences of this?

Describe how the body responds once there is a muscle injury.

How long does it take for an acute inflammatory response to peak?

How does cortisol release relate to muscle damage?

What is the primary function of cortisol release? What three things does this activate?

1.

2.

3.

Describe what free radicals are and how they relate to muscle damage.

Are athletes who train intensely or compete frequently more susceptible to colds and infections?

What are some potential reasons for immune suppression in response to strenuous exercise?

1.

2.

3.

What does cortisol do to the immune system? What causes these effects?

Exercise 4: Hyperhydration

Why is it important for athletes to be properly hydrated before exercise?

What is meant by the term hyperhydrate?

If an athlete hyperhydrates, what happens to the:

1. Sweat rate:
2. Ability to thermoregulate:

Under what conditions is hyperhydration most beneficial?

Explain some of the consequences of hyperhydrating before an exercise bout. How can this be overcome?

What is a recommended hyperhydration fluid? When should hyperhydration begin? How much fluid should be consumed?

Exercise 5: Glycogen Loading

How does the initial muscle glycogen level relate to the rate of use?

What happens to an athlete's ability to perform if the exercise bout is >90 minutes and muscle glycogen stores have been increased before initiating the bout of exercise?

Describe the muscle glycogen stores under the following conditions:

1. Normal range:
2. In response to endurance training:
3. In response to a high-carbohydrate diet:

Who was the first investigator to explore the concept of muscle glycogen loading? What did they find?

Outline the original glycogen-loading regime.

Outline the modified glycogen-loading regime presented by Sherman et al.

Can endurance athletes increase their muscle glycogen stores in as little as 24 hours?

Exercise 6: Preexercise Carbohydrate Feeding

How much carbohydrate should an endurance athlete consume 4–6 hours before exercise?

What are the physiologic responses of this practice?

How important is the consumption of a carbohydrate-rich meal 4–6 hours before exercise? How does it relate to supplementation during the event?

What might be a practical recommendation regarding a preexercise meal 4–5 hours before exercise?

What are the physiologic effects of consuming carbohydrates between 30–60 minutes before the initiation of exercise?

Discuss the literature regarding preexercise carbohydrate supplementation. Does it improve performance?

Exercise 7: Fluid and Electrolyte Supplementation

What are the most important factors that dictate the amount of sweat lost during exercise?

1.

2.

3.

How high can the sweat rate get? How does this relate to the rate of gastric emptying?

What is the general rule about fluid consumption during exercise? Give an example strategy to accommodate this rule.

Why is thirst not a good indicator of fluid requirements or dehydration? Illustrate this point.

What is the major salt lost in sweat?

Why is it important to replace some of the sodium lost in sweat?

1.

2.

3.

What is hyponatremia? What are some characteristics of this?

List eight symptoms of hyponatremia?

1.

2.

3.

4.

5.

6.

7.

8.

What is the mortality rate for acute hyponatremia?

What are two other electrolytes that are found in sweat?

1.

2.

What is the general concentration of electrolytes in sports drinks?

1.

2.

Exercise 8: Carbohydrate Supplementation

One of the first studies to examine the effects of carbohydrate feeding on endurance-exercise performance was conducted by Dill et al. Explain the basics of this landmark investigation.

What are the basic effects of carbohydrate supplementation on exercise performance?

1.

2.

3.

4.

5.

Discuss the mechanism of action by which carbohydrate supplementation affects moderate-intensity exercise performance.

Discuss the mechanism of action by which carbohydrate supplementation affects intermittent or variable-intensity exercise performance.

Does carbohydrate supplementation spare muscle glycogen? Under what conditions?

What is the main objective of using carbohydrate supplements during exercise?

What is the maximal rate of blood glucose oxidation under conditions of euglycemia and low glycogen stores?

What happens to the maximal rate of glucose oxidation when a mix of glucose and fructose are consumed? Glucose and sucrose?

Outline the best amount of exogenous carbohydrate required.

What is the average rate of gastric emptying of a glucose solution? What impacts the rate of gastric emptying?

Discuss the relationship among the glucose emptying rate, the fluid emptying rate, and the glucose content in the supplement.

What happens with gastric emptying of glucose and fluid with supplements that contain >10% glucose?

What dictates the appropriate glucose concentration?

1.

2.

Why can cyclists consume more fluid per hour than runners?

How does the carbohydrate content of supplements differ for runners and cyclists to ensure that the appropriate amount of glucose is available?

How should carbohydrate supplements be timed throughout an exercise bout?

Outline the most important consideration when timing carbohydrate supplements.

Outline a carbohydrate- and fluid-supplementation regime for an athlete who is exercising in a hot and humid environment.

List some carbohydrates that are metabolized at comparable rates to glucose:

1.

2.

3.

What dictates the rate of oxidation of starches?

1.

2.

Why are fructose and galactose oxidized slower than glucose?

Explain some of the consequences of consuming large amounts of fructose.

What happens to the rate of oxidization when glucose is combined with fructose?

What happens to the effectiveness of the supplement if small amounts of protein are added to the beverage?

How do carbohydrate supplements compare with carbohydrate + protein supplements?

Exercise 9: Supplementation to Support the Immune System

What happens to the immune system after exercise? How long does this response last?

What happens to circulating cortisol concentrations in response to carbohydrate supplementation? How does this relate to the immune response?

Detail the responses of the following immune markers to carbohydrate supplementation combined with exercise:

1. T cells:
2. Natural killer cells:
3. Cytokines:
4. IL-6:
5. IL-1β:

Why might adding protein to a carbohydrate beverage affect the immune system?

Exercise 10: Rehydration

What happens when large amounts of water are consumed after exercise-induced dehydration? How does this compare with a beverage that contains electrolytes?

What should be the sodium content of the postexercise beverage?

The general rule of thumb is that the higher the__________ content, the higher the _________ retention.

Sodium content of postexercise drinks should not exceed ____________ $mmol \cdot L^{-1}$ unless the athlete is trying to ______________.

What should the concentration of potassium be in the fluid-replacement beverage?

How much fluid should be consumed postexercise in relation to the amount of body weight lost during the exercise bout?

Exercise 11: Glycogen Repletion

How does the amount of carbohydrate consumed relate to the rate and amount of glycogen resynthesized after exercise? (Give examples.)

What are some recommendations for carbohydrate consumption for:

1. Moderate-training durations and low intensities:
2. Moderate-training durations and high intensities:
3. Training with extreme durations and intensities:

What are three factors that influence the rate of muscle glycogen storage after exercise?

1.
2.
3.

Compare and contrast the rate of muscle glycogen resynthesis after exercise if the supplement is consumed immediately after exercise or delayed several hours. Why does this occur?

The rate of glycogen storage will decrease as the ________________ decreases.

What happens to the rate of glycogen storage if supplements are consumed every 2 hours?

Providing _______________ glucose per kilogram body weight at 2-hour intervals optimizes muscle glycogen storage.

What is the rate of muscle glycogen synthesis when supplementing at 2-hour intervals?

How does providing carbohydrate supplements at 2-hour intervals compare with those provided at 30-minute intervals postexercise? Which is the preferred method?

What happens to glycogen storage if a carbohydrate/protein beverage is consumed at 2-hour intervals after exercise compared with consuming only carbohydrates?

Exercise 12: Initiating Muscle Protein Synthesis and Limiting Muscle Tissue Damage

How does insulin affect protein synthesis and degradation postexercise?

How do carbohydrate supplements taken postexercise affect:

1. Insulin:
2. Protein synthesis:
3. Urinary nitrogen:
4. 3-Methylhistidine:

What happens to the protein synthesis rate if plasma amino acid levels decrease after exercise?

How does the inclusion of amino acids with a carbohydrate beverage affect protein synthesis?

What happens if the plasma level of essential amino acids is increased to protein synthesis rates?

The consumption of different types of protein can impact the protein synthesis rate. Describe the results of consuming the following proteins sources on protein synthesis rates:

1. Whey protein:
2. Casein protein:

What happens to the rate of protein synthesis if the amino acid + carbohydrate beverage is delayed for 3 hours compared with consumption immediately after exercise?

What happens to protein accretion and muscle glycogen storage with protein + carbohydrate supplements?

Exercise 13: Carbohydrate/Protein Supplements and Immune Response

What are the effects of postexercise carbohydrate/protein supplements on the following compared with not supplementing at all?

1. Total medical visits:
2. Medical visits for bacterial/viral infections:
3. Medical visits for muscle and joint problems:
4. Muscle soreness:

Review Test

1. The primary means of dissipating heat during exercise is through:
   a. Convection
   b. Conduction
   c. Evaporation
   d. None of the above

2. Janna loses 2 L of water through evaporation. How many kilocalories of heat are dissipated from the body and transferred to the environment?
   a. 1160
   b. 580
   c. 290
   d. 145

3. A loss of body fluid approximately equal to 1% of body weight does not produce any deleterious effects.
   a. True
   b. False

4. What percentage of body weight loss as a result of fluid loss can cause heat stroke?
   a. 1%
   b. 4%
   c. 6%
   d. None of the above

5. An imbalance in electrolytes can occur as a consequence of dehydration.
   a. True
   b. False

6. A typical plasma sodium concentration ranges between ________ $mmol \cdot L^{-1}$.
   a. 96–110
   b. 130–155
   c. 20–60
   d. None of the above

7. The liver stores approximately ________ g of glycogen.
   a. 600–800
   b. 300–500
   c. 75–100
   d. None of the above

8. All of the following occur with reductions of muscle glycogen and or blood glucose except:
   a. Fatigue as a result of failure to meet energy demands
   b. At low intensities, there is evidence of central nervous system limitations
   c. During high-intensity aerobic exercise, muscle glucose uptake is too slow to support the carbohydrate needs of the muscles
   d. During high-intensity aerobic exercise, there is an accumulation of high lactic acid and a reduction of high-energy phosphates

9. At moderate-intensity exercise, glucose uptake can support the carbohydrate needs of the exercising muscles.
   a. True
   b. False

10. The muscle damage associated with endurance training occurs as a result of disruptions to the muscle membrane and contractile proteins.
    a. True
    b. False

11. All of the following are associated with cortisol except:
    a. As blood glucose levels decrease, cortisol levels increase
    b. Cortisol deactivates glycogenesis
    c. Cortisol activates lipolysis
    d. Cortisol deactivates proteolysis

12. One of the effects of cortisol is to increase the concentrations of important immune cells that fight infection.
    a. True
    b. False

13. A general recommendation for endurance athletes is to consume _________ mL of fluid 2 hours before exercise.
    a. 100
    b. 300
    c. 500
    d. 700

14. The effect of increasing the level of muscle glycogen before an endurance event on the rate of muscle glycogen utilization:
    a. Increased
    b. Decreased
    c. No effect

Match the following muscle glycogen level with the appropriate condition.

15. ________ Normal glycogen levels A) 140–150 $\mu mol \cdot g^{-1}$

16. ________ Endurance trained B) 90–100 $\mu mol \cdot g^{-1}$

17. ________ High-carbohydrate diet C) 120–130 $\mu mol \cdot g^{-1}$

18. How many grams of carbohydrate should an endurance athlete consume 4–6 hours before exercise?
    a. 700–800
    b. 200–300
    c. 50–100
    d. None of the above

19. Hyponatremia can cause symptoms such as:
    a. Cramping
    b. Nausea
    c. Muscle weakness
    d. All of the above

20. An athlete who performs training of moderate duration and low intensity should consume ________ g carbohydrate$\cdot kg^{-1}$ body weight per day.
    a. 5–7
    b. 10–12
    c. 7–12
    d. 20–25

Review of Terminology

Dehydration	**Depletion of Carbohydrate Stores**	**Consequences of Endurance Exercise**
Conduction	Glucose	Cortisol
Convection	Glycogen	Eccentric
Electrolytes	High-Energy Phosphates	Free Radicals
Evaporation		Gluconeogenesis
Heat Cramps	**Glycogen Loading**	Immunosuppression
Heat Exhaustion	Carbohydrate Loading	Lipolysis
Heat Stroke		Proteolysis
	Fluid and Electrolyte Supplementation	Swelling
	Hyponatremia	
Carbohydrate Supplementation	Hypotonic	**Rehydration**
Euglycemia	Plasma	Diuresis
Exogenous		Hypohydrated
Fructose	**Immune System**	
Galactose	Cytokines	**Muscle Glycogen Repletion**
Maltodextrins	Natural Killer Cells	Isocaloric
Maltose	T Cells	Iso-Carbohydrate
Sucrose		
Muscle Protein Synthesis		
3-Methylhistidine		
Accretion		
Protein Degradation		
Protein Synthesis		
Urinary Nitrogen		

Important Abbreviations

IL-1β	
IL-6	
VO_2 max	

28
Nutrition Before, During, and After Exercise for the Strength/Power Athlete

Objectives

On the completion of this chapter, you will be able to:

1. Understand the physiologic effects of strength/power training and how they relate to nutritional interventions.
2. Discuss the importance of preexercise nutrition.
3. Outline a preexercise nutrition intervention that targets the specific needs of the strength/power athlete.
4. Provide a rationale for a nutrition intervention strategy that is used during a bout of strength/power training.
5. Recommend a nutrition intervention that can be used during training by strength/power athletes.
6. Appreciate the importance of postexercise nutrition.
7. Formulate a postexercise intervention that targets the specific needs of a strength/power athlete.

Learning Exercises

Exercise 1: Factors Associated with Strength/Power Performance

What are some varieties of resistance training used by athletes?

1.

2.

3.

List the two major types of muscle proteins that slide back and forth over each other during muscular contractions.

1.

2.

Discuss how muscle mass is built. Be specific in your discussion.

How are muscle contractions powered? What is the major energy conveyer?

What is creatine phosphate's role in muscular contraction?

Discuss the role of glycogen metabolism in strength/power performances.

Does resistance training result in significant reductions in muscle glycogen levels? Give examples.

List the benefits of chronic resistance training:

1.

2.

3.

4.

5.

Which phase of a muscle action results in the most muscle damage?

What is DOMS, and how long does it usually take for it to set in?

What is cortisol? When and why is it released?

List some of the major effects of cortisol release (hint: in relation to metabolism):

1.

2.

3.

Discuss how diet could impact resistance-training adaptations.

Exercise 2: Preexercise Nutrition for the Strength/Power Athlete

What type of carbohydrates should comprise the preexercise meal for the strength/power athlete?

Preexercise meals should be consumed between _______ and _________ hours before strength training.

Why is breakfast the most important meal of the day?

What does the term glycemic index (GI) mean? How is it determined?

Explain the value of consuming a carbohydrate + protein supplement 30–60 minutes before the initiation of exercise.

What are the anabolic actions of insulin?

How do preexercise amino acids affect protein synthesis?

How does consuming EAC before exercise compare with consuming the EAC immediately after exercise? How does this affect muscle protein synthesis?

Fill in the following table comparing preexercise carbohydrate supplements with amino acid (protein) supplementation:

	Carbohydrate	Protein
Type I fiber hypertrophy		
Type II fiber hypertrophy		
Squat jump height		
Type I muscle fCSA		
Type II muscle fCSA		
Countermovement vertical jump height		
Peak torque during slow isokinetic muscle contractions		

Define the following terms:

1. Protein synthesis:
2. Protein breakdown:
3. Net protein balance:

Exercise 3: Nutrition During Exercise for the Strength/Power Athlete

Convenient supplements that can be used during strength/power training are:

1.
2.
3.
4.
5.

How do solid and liquid carbohydrate/protein supplements differ in their effects? Are there any conditions in which liquids are better than solids?

Discuss why carbohydrates are an important component of a supplement regime designed to provide energy during exercise.

What is glycogenolysis and how does strength/power training affect it?

Why is it important for strength/power athletes to ingest fluids and electrolytes when a training bout or competition lasts >1 hour?

List and explain the reasons many athletes do not replenish fluids and carbohydrates fast enough during exercise:

1.

2.

What are the differences among sucrose, fructose, and glucose?

Why should one avoid consuming fructose while exercising?

List three side effects of consuming large quantities of fructose during exercise:

1.

2.

3.

Explain the use of glucose/electrolyte solution (GES) supplements for prolonged endurance exercise.

How do carbohydrate supplements affect muscle glycogen stores when consumed during a resistance-training bout?

What two things might a carbohydrate supplement stimulate when it is consumed during a bout of resistance training?

1.

2.

List four hormonal changes that occur when a combination of carbohydrates and protein are consumed during exercise:

1.

2.

3.

4.

How does the a 4:1 combination of carbohydrate to protein affect the following:

1. Time to fatigue:

2. Muscle damage:

Why is whey protein the preferred protein consumed during exercise?

How often should a 4:1 combination of carbohydrates to protein be consumed during exercise?

What is whey protein? Where does it come from?

What is casein protein? Where does it come from?

What is soy protein? Where does it come from?

Exercise 4: Postexercise Nutrition for the Strength/Power Athlete

What are three reasons why postexercise nutrition is vital for the strength/power athlete?

1.

2.

3.

After exercise, the body is in a(n) ___________ state.

________________ is activated by glycogen depletion.

What is the rate-limiting step in the formation of glycogen? Explain.

Next to the carbohydrate supplement, list the type of glycogen it most replenishes.

1. Glucose: ____________________
2. Fructose: ___________________
3. Glucose polymers: _____________

The insulin response is ______________ in glucose than in fructose.

What percent of the total carbohydrates stored in the body are stored in the:

1. Liver: __________________
2. Skeletal muscle: __________________

Discuss the effectiveness of the following sources of carbohydrate on their ability to replenish muscle glycogen. (Hint: How do they differ?)

1. Glucose:
2. Fructose:
3. Sucrose:

What stimulates an increase in postexercise muscle glycogen synthesis?

Why is it important to ingest high GI carbohydrates after exercise?

Compare and contrast the effects of a diet of simple carbohydrates with a complex carbohydrate diet. (Hint: Are they absorbed differently?)

Discuss the effects of consuming a mixed carbohydrate/protein/fat meal immediately after or 3 hours after an acute exercise bout. How do these practices affect the hormonal environment, protein synthesis, proteolysis?

What does the addition of protein to a postexercise carbohydrate supplement do to muscle glycogen resynthesis?

Does insulin have anabolic effects? What are they?

Compare the effects of a mixture of amino acids and carbohydrates with that of carbohydrates alone. How do they differ in their effects on net protein balance, protein synthesis rates, etc.?

Outline a general postexercise supplementation regime for a strength/power athlete. (Hint: Include the composition of the supplement as well as the timing.)

Fill in the following table in regard to insulin's effects:		
	High insulin concentration	Low insulin concentration
Rate of glucose entry into the cell		
Net synthesis rate		
Glycogen		
Triglycerides		
Protein		
Glycogenesis		
Lipolysis		
Note: ⇑ = increase, ⇓ = decrease.		

Discuss how postexercise carbohydrate, and carbohydrate + protein supplements affect medical visits in Marines:

1. Total medical visits:
2. Visits as a result of viral/bacterial infections:
3. Visits as a result of muscle and joint problems:
4. Visits as a result of heat exhaustion:

Review Test

1. One of the two muscle proteins that interact during contraction is:
   a. Actin
   b. Myosin
   c. Tropomyosin
   d. a and b
   e. a and c

2. One set of 10 biceps curls can reduce muscle glycogen by as much as:
   a. 40%
   b. 32%
   c. 12%
   d. 35%

3. Muscular stores of creatine phosphate can be depleted in:
   a. 10–15 seconds
   b. 5–10 seconds
   c. 20–30 seconds
   d. None of the above

4. During high-intensity resistance training, cortisol can be released, causing all of the following except:
   a. Increased gluconeogenesis
   b. Increased glycogenesis
   c. Increased lipolysis
   d. Increased proteolysis

5. Habitual resistance training can result in:
   a. Decrease in percent body fat
   b. Increased muscular strength
   c. Decreased glucose control
   d. a and b
   e. b and c

6. Generally, it is not recommended that strength/power athletes be concerned with consuming carbohydrates 4–6 hours before the initiation of an exercise bout.
   a. True
   b. False

7. An example of a high glycemic index carbohydrate is:
   a. Dextrose
   b. Fructose
   c. Maltodextrin
   d. Sucrose

8. Consuming ___________ 30–60 minutes before an intense bout of exercise can result in increased carbohydrate availability toward the end of the bout.
   a. 5–10 g of carbohydrate and 50 g of protein
   b. 5–10 g of carbohydrate and 5–10 g of protein
   c. 50 g of carbohydrate and 5–10 g of protein
   d. 50 g of carbohydrate and 50 g of protein

9. Increases in insulin seem to offset the catabolic effects of cortisol and inhibit protein degradation.
   a. True
   b. False

10. Consuming an oral essential amino acid supplement results in significantly more protein synthesis when ingested before training as compared with consumption after a training bout.
    a. True
    b. False

11. All of the following are results of protein supplementation before and immediately after training except:
    a. Hypertrophy of type I fibers
    b. Increased squat jump height
    c. Increased countermovement jump height
    d. Hypertrophy of type II fibers

12. Liquid dietary supplements seem to provide the added benefit of rapid digestion because they often contain low glycemic index carbohydrates.
    a. True
    b. False

13. All of the following occur as a result of increasing exercise intensity except:
    a. Increased rate of glycogenolysis
    b. Increased energy supply from blood glucose
    c. Increased plasma fatty acid turnover
    d. Increased lactate formation

14. Glucose/electrolyte solutions have the potential to:
    a. Maintain blood glucose levels
    b. Prevent dehydration
    c. Spare muscle glycogen
    d. All of the above

15. The effect of glucose/electrolyte solutions on immunosuppression:
    a. Increased
    b. Decreased
    c. No effect

16. Fructose is considered the carbohydrate of choice because it does not produce gastrointestinal discomfort or diarrhea in strength/power athletes.
    a. True
    b. False

17. Consuming carbohydrates during a resistance-training bout can:
    a. Inhibit glycogenolysis
    b. Stimulate glycogen synthesis during rest intervals
    c. a and b
    d. None of the above

18. The effect of combining carbohydrates with protein on the insulin response:
    a. Increased
    b. Decreased
    c. No effect

19. Whey protein should be consumed during exercise because:
    a. It is rapidly absorbed
    b. It has a high percentage of glutamine
    c. It has all of the essential amino acids
    d. All of the above

20. Postexercise supplements are used in order to:
    a. Restore muscle glycogen stores
    b. Stimulate muscle fiber growth and repair
    c. Shift the anabolic state stimulated by the exercise out to a catabolic state
    d. a and c
    e. a and b

Review of Terminology

Factors Associated with Strength/Power Performance	**Preexercise Nutrition**	**Nutrition During Exercise**
Actin	Catabolic	Casein
Adenosine Diphosphate	Essential Amino Acids	Cortisol
Adenosine Triphosphate	Glycemic Index	Energy Bars
Bodybuilding	Hypertrophy	Fructose
Cortisol	Muscle Protein Balance	Glucose
Creatine Phosphate	Oral Glucose Tolerance Test	Glucose/Electrolyte Solution
Delayed Onset Muscle Soreness	Phenylalanine	Glycogen Synthesis
Gluconeogenesis	Protein Synthesis	Glycogenolysis
Glycogen	Type I	Growth Hormone
Lipolysis	Type II	Hormonal Milieu
Myosin		Insulin
Olympic Weightlifting		Meal Replacement Powders
Overtraining	**Postexercise Nutrition**	Ready to Drink Supplements
Power Lifting	Amylase Chain	Soy Protein
Proteolysis	Glucose Polymer	Sucrose
	Glycogen Synthase	Testosterone
	Glycogenesis	Whey Protein
	Lipolysis	
	UDP-glucose	

Important Abbreviations

ADP	GES
ATP	GI
CP	MRPs
DOMS	OGT
EAC	RTDs
fCSA	UDP

Part VI
Appendix

Appendix
Answers to Quiz Questions

Chapter 1

Question	Answer
1	a
2	b
3	c
4	c
5	d
6	a
7	b
8	d
9	c
10	b
11	a
12	b
13	c
14	a
15	d
16	a
17	a
18	d
19	b
20	c

Chapter 2

Question	Answer
1	c
2	a
3	b
4	c
5	b
6	f
7	b
8	c
9	b
10	a
11	b
12	a
13	b
14	a
15	c
16	a
17	a
18	c
19	b
20	e

Chapter 3

Question	Answer
1	a
2	e
3	f
4	b
5	a
6	b
7	b
8	a
9	c
10	b
11	b
12	f
13	a
14	b
15	b
16	c
17	f
18	b
19	d
20	c

Chapter 4

Question	Answer
1	c
2	b
3	c
4	a
5	c

Chapter 5

Question	Answer
1	c
2	e
3	b
4	a
5	b

Chapter 6

Question	Answer
1	b
2	f
3	d
4	e
5	a

Chapter 4

Question	Answer
6	a
7	b
8	f
9	d
10	b
11	c
12	b
13	a
14	c
15	a
16	e
17	b
18	a
19	a
20	b

Chapter 5

Question	Answer
6	a
7	d
8	b
9	c
10	a
11	d
12	b
13	a
14	b
15	c
16	b
17	b
18	a
19	c
20	c

Chapter 6

Question	Answer
6	a
7	e
8	b
9	c
10	d
11	b
12	c
13	d
14	a
15	b
16	d
17	a
18	b
19	c
20	a

Chapter 7

Question	Answer
1	a
2	d
3	b
4	a
5	c
6	b
7	a
8	c
9	d
10	b
11	b
12	b
13	a
14	c
15	d
16	b
17	a
18	c
19	b
20	a

Chapter 8

Question	Answer
1	b
2	e
3	c
4	b
5	a
6	c
7	e
8	a
9	c
10	b
11	e
12	c
13	b
14	a
15	a
16	c
17	b
18	b
19	a
20	e

Chapter 9

Question	Answer
1	b
2	c
3	c
4	a
5	d
6	c
7	b
8	a
9	b
10	c
11	b
12	a
13	c
14	d
15	a
16	e
17	c
18	a
19	b
20	d

Chapter 10

Question	Answer
1	b
2	f
3	c
4	a
5	d
6	a
7	b
8	c
9	e
10	b
11	c
12	b
13	d
14	a
15	c
16	b
17	d
18	c
19	b
20	a

Chapter 11

Question	Answer
1	a
2	c
3	b
4	d
5	a
6	c
7	d
8	b
9	a
10	c
11	b
12	d
13	b
14	c
15	b
16	d
17	b
18	b
19	a
20	c

Chapter 12

Question	Answer
1	a
2	d
3	e
4	c
5	b
6	a
7	b
8	c
9	a
10	c
11	e
12	a
13	b
14	c
15	b
16	d
17	a
18	b
19	d
20	a

Chapter 13

Question	Answer
1	c
2	d
3	a
4	b
5	a
6	c
7	d
8	b
9	a
10	d
11	b
12	d
13	a
14	b
15	c
16	b
17	d
18	b
19	a
20	d

Chapter 14

Question	Answer
1	b
2	c
3	d
4	a
5	c
6	b
7	d
8	d
9	e
10	d
11	a
12	b
13	a
14	c
15	b
16	c
17	a
18	d
19	a
20	b

Chapter 15

Question	Answer
1	d
2	b
3	a
4	e
5	c
6	c
7	f
8	c
9	b
10	a
11	c
12	d
13	b
14	a
15	c
16	b
17	e
18	d
19	b
20	a

Chapter 16

Question	Answer
1	b
2	c
3	b
4	a
5	d
6	c
7	a
8	b
9	e
10	b
11	c
12	b
13	d
14	a
15	b
16	a
17	c
18	b
19	d
20	a

Chapter 17

Question	Answer
1	b
2	d
3	a
4	b
5	b
6	d
7	c
8	a
9	b
10	a
11	d
12	e
13	b
14	a
15	b
16	d
17	a
18	c
19	b
20	a

Chapter 18

Question	Answer
1	c
2	b
3	d
4	a
5	c
6	b
7	d
8	a
9	b
10	a
11	c
12	e
13	b
14	d
15	a
16	b
17	a
18	d
19	c
20	b

Chapter 19

Question	Answer
1	d
2	a
3	c
4	b
5	d
6	a
7	c
8	b
9	d
10	d
11	b
12	c
13	d
14	a
15	c
16	a
17	b
18	b
19	c
20	c

Chapter 20

Question	Answer
1	d
2	a
3	b
4	c
5	a
6	b
7	c
8	d
9	e
10	b
11	c
12	b
13	a
14	d
15	a
16	e
17	b
18	c
19	b
20	d

Chapter 21

Question	Answer
1	a
2	e
3	c
4	b
5	b
6	d
7	a
8	c
9	b
10	e
11	b
12	c
13	d
14	a
15	b
16	c
17	a
18	d
19	d
20	b

Chapter 22

Question	Answer
1	b
2	a
3	c
4	b
5	d
6	c
7	d
8	b
9	d
10	d
11	b
12	a
13	c
14	e
15	b
16	e
17	c
18	b
19	a
20	b

Chapter 23

Question	Answer
1	c
2	b
3	a
4	c
5	a
6	d
7	a
8	b
9	b
10	a
11	c
12	a
13	b
14	e
15	d
16	c
17	d
18	d
19	a
20	c

Chapter 24

Question	Answer
1	c
2	e
3	b
4	a
5	d
6	d
7	c
8	e
9	b
10	a
11	a
12	b
13	a
14	c
15	d
16	c
17	a
18	d
19	a
20	d

Chapter 25

Question	Answer
1	b
2	c
3	e
4	a
5	d
6	a
7	c
8	b
9	e
10	a
11	d
12	b
13	b
14	a
15	d
16	b
17	a
18	a
19	d
20	c

Chapter 26

Question	Answer
1	b
2	a
3	c
4	b
5	b
6	c
7	a
8	e
9	d
10	b
11	a
12	b
13	b
14	a
15	e
16	a
17	a
18	b
19	c
20	e

Chapter 27

Question	Answer
1	c
2	a
3	b
4	c
5	a
6	b
7	c
8	b
9	a
10	a
11	d
12	b
13	c
14	a
15	b
16	c
17	a
18	b
19	d
20	c

Chapter 28

Question	Answer	Question	Answer	Question	Answer
1	d	8	c	15	b
2	c	9	a	16	b
3	a	10	a	17	c
4	b	11	c	18	a
5	d	12	b	19	d
6	b	13	c	20	e
7	a	14	d		

About the Author

G. Gregory Haff, PhD

Dr. Greg Haff received his Master of Science degree in exercise science from Appalachian State University in 1996. While at ASU, he focused his research efforts on three broad areas: 1) training theory, 2) dietary supplementation, and 3) biomechanical markers of athlete preparedness. After completing his time at ASU, he entered the University of Kansas's Doctoral Program in Education where he specialized in Exercise Physiology. While at the University of Kansas, Dr. Haff performed research that explored the use of carbohydrate supplements by strength/power athletes, creatine supplementation, and immune responses to resistance-training bouts. After graduating from the University of Kansas in 1999, Dr. Haff became the Neuromuscular Laboratory Director at Appalachian State University. From 1999 to 2002, Dr. Haff served in this capacity. In 2001, Dr. Haff was named the Young Investigator of the Year by the National Strength and Conditioning Association for his sports science-based research. In 2002, Dr. Haff moved to Wichita Falls, Texas, where he took over the United States Weightlifting Regional Development Center at Midwestern State University. While at MSU, Dr. Haff became the Department Chair, Director of the Human Performance Laboratory, and Director of the Strength Research Laboratory. After 2 years in Texas, Dr. Haff was recruited by the Division of Exercise Physiology at West Virginia University to help broaden the departmental focus. Currently, Dr. Haff is perusing research focused on the effects of anabolic steroids on muscle morphology and apoptosis. Additionally, Dr. Haff is assisting Dr. Guy Hornsby with his research in high-intensity resistance training and Type I diabetics. Finally, Dr. Haff is a Certified Strength and Conditioning Specialist, a Regional Level Weightlifting Coach, and a Level 3 Cycling Coach. Dr. Haff competed nationally in weightlifting from 1989 to 2000, and has competed in track cycling.