Twelfth Edition

WILLIAMS' NUTRITION

FOR HEALTH, FITNESS & SPORT

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Old Dominion University

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WILLIAMS' NUTRITION FOR HEALTH, FITNESS & SPORT, TWELFTH EDITION

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Dedication

In memory of Melvin H. Williams

We dedicate this twelfth edition to the founding author, Melvin H. Williams. We are honored to carry on the legacy of a friend and respected colleague in the nutrition field.

To Debbie, Christopher, Matthew, and Erica
—*Eric S. Rawson*

To Carol, David, Molly, Anne Randolph, Gracie, and the rest of my family
—*J. David Branch*

To Brian, Bailey, Kylie Mae, and Ansley
—*Tammy J. Stephenson*

and

To our teachers, colleagues, and students
Eric, David, and Tammy

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About the Authors

Courtesy of Eric Foster, Bloomsburg University

Eric S. Rawson, PhD, FACSM, CSCS, is Chair and Professor of Health, Nutrition, and Exercise Science at Messiah College in Mechanicsburg, Pennsylvania. Dr. Rawson received his PhD from the University of Massachusetts, Amherst, where he studied under the direction of Dr. Priscilla Clarkson. Over the past two decades, Dr. Rawson's research has focused on the interactions between nutrition and skeletal muscle. In particular, Dr. Rawson has extensively studied the effects of the dietary supplement creatine on muscle and brain function. Dr. Rawson has been an active member in the American College of Sports Medicine (ACSM) since 1996, has served on the ACSM Board of Trustees, on the ACSM Annual Meeting Program Committee, as Chair of the ACSM National Chapter Nutrition Interest Group, and is a past president of the Mid-Atlantic ACSM regional chapter. Dr. Rawson has delivered more than 150 professional presentations, is co-editor of the text *Nutrition for Elite Athletes,* co-author of the eleventh and twelfth editions of *Nutrition for Health, Fitness & Sport,* and has authored/co-authored numerous articles and book chapters. His research has been funded by the National Institutes of Health and various foundations.

Courtesy of Chuck Thomas, University Photographer, Old Dominion University

J. David Branch, earned a BA degree from Furman University, and MS and PhD degrees in Exercise Science from the University of South Carolina. Since 1994, he has been at Old Dominion University in the Department of Human Movement Sciences, where he has taught exercise physiology, exercise testing, research methods, and other courses in the undergraduate and graduate exercise science programs. Prior to that, he was a lecturer at Furman University and worked for many years in a facility specializing in health and fitness testing of South Carolina law enforcement personnel. He is a Fellow in the American College of Sports Medicine. Dr. Branch enjoys reading, running, the beach, spending time with wife Carol, dog Gracie, grand dog Banks, and the accomplishments of his adult children, David and Anne Randolph.

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Courtesy of Tammy Stephenson

Tammy J. Stephenson, PhD, received her BS degree in Food Science and Human Nutrition, and PhD in Nutritional Sciences from the University of Kentucky. She has taught a variety of food, nutrition, and wellness courses, including sports nutrition and introductory nutrition, in the Department of Dietetics and Human Nutrition at the University of Kentucky for the past 20 years. Dr. Stephenson serves as Director of Undergraduate Studies for the Dietetics and Human Nutrition degree programs, as Director of the Undergraduate Certificate in Food Systems and Hunger Studies, and as Co-Director of the Undergraduate Certificate in Nutrition for Human Performance. She has been recognized with multiple teaching and advising awards at the university, state, and national levels, including the University of Kentucky Alumni Association's Great Teacher Award (2016) and the Provost Office's Outstanding Teacher Award (2015). Dr. Stephenson is an active member of the Academy of Nutrition and Dietetics, having served as Chair of the Nutrition Educators of Health Professionals practice group. She is also a member of the Sports, Cardiovascular, and Wellness Nutrition practice group of the Academy. Dr. Stephenson is co-author of *Human Nutrition: Science for Healthy Living,* now in its second edition. Outside of the classroom, she enjoys running, yoga, hiking, reading, gardening, watching her daughters play sports, and spending time with her family.

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Preface

According to the World Health Organization, better health is the key to human happiness and well-being. Many factors influence one's health status, including some shared by various government and health agencies, such as safe living environments and access to proper health care. However, in general, one's personal health over the course of a lifetime is dependent more upon personal lifestyle choices, two of the most important being proper exercise and healthy eating.

In the twenty-first century, our love affair with fitness and sports continues to grow. Worldwide, although rates of physical inactivity are still prevalent in developed nations, there are millions of children and adults who are active in physical activities such as bicycling, running, swimming, walking, and weight training. Improvements in health and fitness are major reasons more and more people initiate an exercise program, but many may also become more interested in sports competition, such as age-group road racing; running and walking race competitions have become increasingly popular, and every weekend numerous road races can be found within a short drive. Research has shown that adults who become physically active also may become more interested in other aspects of their lifestyles—particularly nutrition—that may affect their health in a positive way. Indeed, according to all major health organizations, proper exercise and a healthful diet are two of the most important lifestyle behaviors to help prevent chronic disease.

Nutrition is the study of foods and their effects upon health, development, and performance. Over the years, nutrition research has made a significant contribution to our knowledge of essential nutrient needs. During the first part of the twentieth century, most nutrition research focused on identification of essential nutrients and amounts needed to prevent nutrient-deficiency diseases, such as scurvy from inadequate vitamin C. As nutrition science evolved, medical researchers focused on the effects of foods and their specific constituents as a means to help prevent the major chronic diseases, such as heart disease and cancer, that are epidemic in developed countries. *Nutriceutical* is a relatively new term used to characterize the drug, or medical, effects of a particular nutrient. Recent research findings continue to indicate that our diet is one of the most important determinants of our health status. Although individual nutrients are still being evaluated for possible health benefits, research is also focusing on dietary patterns, or the totality of the diet, and resultant health benefits. However, we should note that research relative to the effects of diet, including specific nutrients, on health is complex and dietary recommendations may change with new research findings. For example, as noted later in the text, the guidelines regarding dietary intake of cholesterol have been modified after being in effect for more than 50 years.

Other than the health benefits of exercise and fitness, many physically active individuals are also finding the joy of athletic competition, participating in local sports events such as golf tournaments, tennis matches, triathlons, and road races. Individuals who compete athletically are always looking for a means to improve performance, be it a new piece of equipment or an improved training method. In this regard, proper nutrition may be a very important factor in improving sports performance. Various sports governing agencies indicate today's athletes need accurate sports nutrition information to maximize sports performance. Although the effect of diet on sports and exercise performance was studied only sporadically prior to 1970, subsequently numerous sports scientists and sports nutritionists have studied the performance-enhancing effects of nutrition, such as diet composition and dietary supplements. Results of these studies have provided nutritional guidance to enhance performance in specific athletic endeavors. In the United States, many universities and professional sports teams, such as those in Major League Baseball, the National Hockey League, and the National Football League, employ registered dietitian nutritionists as well as culinary chefs to provide dietary guidance to their athletes.

With the completion of the Human Genome Project, gene therapies are being developed for the medical treatment of various health problems. Moreover, some contend that genetic manipulations may be used to enhance sports performance. For example, gene doping to increase insulin-like growth factor, which can stimulate muscle growth, may be applied to sport.

Our personal genetic code plays an important role in determining our health status and our sports abilities, and futurists speculate that one day each of us will carry our own genetic chip that will enable us to tailor food selection and exercise programs to optimize our health and sports performance. Such may be the case, but for the time being we must depend on available scientific evidence to provide us with prudent guidelines.

Each year thousands of published studies and reviews analyze the effects of nutrition on health or exercise and sports performance. The major purpose of this text is to evaluate these scientific data and present prudent recommendations for individuals who want to modify their diet for optimal health or exercise/sports performance.

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Textbook Overview

This book uses a question-answer approach, which is convenient when you may have occasional short periods to study, such as riding a bus or during a lunch break. In addition, the questions are arranged in a logical sequence, the answer to one question often leading into the question that follows. Where appropriate, cross-referencing within the text is used to expand the discussion. No deep scientific background is needed for the chemical aspects of nutrition and energy expenditure, as these have been simplified. Instructors who use this book as a course text may add details of biochemistry as they feel necessary.

Chapter 1 introduces you to the general effects of exercise and nutrition on health-related and sports-related fitness, including the importance of well-controlled scientific research. Chapter 2 provides a broad overview of sound guidelines relative to nutrition for optimal health and physical performance. Chapter 3 focuses on energy and energy pathways in the body, the key to all exercise and sports activities.

Chapters 4 through 9 deal with the six basic nutrients—carbohydrate, fat, protein, vitamins, minerals, and water—with emphasis on the health and performance implications for the physically active individual. Chapters 10 through 12 review concepts of body composition and weight control, with suggestions on how to gain or lose body weight through diet and exercise, as well as the implications of such changes for health and athletic performance. Chapter 13 covers alcohol and caffeine, and other related dietary supplements and ergogenic aids regarding their effects on health and exercise performance. Four appendices complement the text, providing detailed metabolic pathways for carbohydrate, fat, and protein, methods to determine healthy body weight, units of measurement: English System–Metric System equivalents, and approximate energy expenditure by body weight.

New to the Twelfth Edition

The first edition of this textbook, titled *Nutrition for Fitness and Sport,* was published in 1983. As one would expect, much has changed in the fields of nutrition and exercise science over the past 35 years. This edition of the textbook has been updated with the most current research available from evidence-based sources regarding the effects of nutritional choices on health, fitness, and sports performance. New features and updated assessments, including critical thinking questions, make the textbook user-friendly and help students learn and apply content. The new *Training Table* feature is embedded throughout the chapters and provides practical and relevant examples and content on a variety of topics related to physical activity and nutrition. As instructors ourselves, we hope that both faculty and students find the textbook engaging, informative, relevant, and interesting.

As you read through the twelfth edition of the textbook, the following updates have been made.

Chapter 1—Introduction to Nutrition for Health, Fitness, and Sports Performance

- New information on the leading causes of death in the United States with an expanded discussion of those related to diet and/or physical activity
- New Training Tables on current and interesting topics such as *Healthy People 2020* objectives, examples of physical activity options at different intensities, and nutritional quackery
- Reorganization of chapter content to enhance flow and readability
- Physical activity guidelines section updated with the current recommendations and specific examples
- New content on the physical activity habits of Americans with new figure 1.5 map of the United States showing the percentage of the population who are physically inactive in each state
- The most current information available on fitness trackers and heart rate monitors, including a new figure 1.6 showing different options
- Specific recommendations from the *2015–2020 Dietary Guidelines for Americans,* including an expanded discussion of those guidelines
- Updated Prudent Healthy Diet recommendations based on the most current evidence available, including recommendations that focus on the type of fat consumed, versus just limiting all fat; and general recommendations related to protein intake
- An introduction to ergogenic aids and general advice about their use, with specific details embedded throughout subsequent chapters
- New guidelines on evaluating and understanding different types of research studies and making evidence-based recommendations
- A new Application Exercise based on a case-study scenario
- Innovative Critical Thinking Questions that challenge students to go beyond memorizing content, and to truly apply the material
- New and revised references

Chapter 2—Healthful Nutrition for Fitness and Sport

- Many new and revised tables including table 2.1, reorganized to enhance readability, listing nutrients essential or probably essential to humans; table 2.3 listing the Acceptable Macronutrient Distribution Ranges (AMDRs) for adults; and table 2.4 providing key information about the different food groups and sample serving size equivalents
- New Training Tables on topics including food sources of empty calories, healthy eating on a budget, and limiting sodium intake
- Revised section with new information on how dietary recommendations are set, and a new figure 2.2 showing the relationship between RDAs, AIs, ULs, and others
- New MyPlate content
- Condensed content on the Food Exchange System and an expanded discussion of carbohydrate counting as an alternative
- Updated figure 2.5 demonstrating the concept of nutrient density when comparing two products
- Specific dietary advice based on the most currently available literature and recommendations from evidence-based sources, including significantly revised sections on whole grains, dietary fat, added sugars, and vegetarianism
- New figure 2.11 showing the most current Nutrition Facts panel approved by the U.S. Food and Drug Administration (FDA), with text discussions on what changes were made and advice pertaining to the use of those labels

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- New content related to classification and monitoring of dietary supplements with practical advice on how supplements can be a healthy addition to a well-balanced diet
- Introduction of key concepts of sports nutrition with practical recommendations and guidance, including specific examples of precompetition meals
- A new Application Exercise based on a case-study scenario
- New Critical Thinking Questions
- New and revised references

Chapter 3—Human Energy
- Enhanced discussion of techniques to measure physical activity and energy expenditure, including the use of various commercial apps
- Updated figures and images
- New and revised references

Chapter 4—Carbohydrates: The Main Energy Food
- Removal of Food Exchanges content
- New data on the effectiveness of carbohydrate mouth rinse on resistance exercise performance
- New Training Tables on topics such as simplifying carbohydrate recommendations, carbohydrate recommendations based on energy expenditure, and optimizing dietary fiber intake
- Updated carbohydrate Key Concepts
- Updated data on ergogenic aspects of carbohydrate
- New data on the effects of sugar and fiber ingestion on health
- Updated information on gluten-free diets
- New information on low FODMAP diets
- New and revised references

Chapter 5—Fat: An Important Energy Source during Exercise
- New information on dietary cholesterol intake from the *2015–2020 Dietary Guidelines for Americans*
- New data on the effects of low-carbohydrate, high-fat diets in endurance athletes
- New Training Tables on the topics of ketogenic diets and endurance exercise performance, low-fat versus high-fat diets for weight loss, the coconut oil dietary fad, the International Olympic Committee (IOC) dietary supplement consensus for athletes, and dietary guidelines to reduce or maintain serum lipid levels
- Updated information on the benefits of a low-fat diet on breast cancer
- New data on the effects of intermittent fasting on weight loss and health
- New data on the effects of omega-3 fat intake on cognitive and muscle functions and health
- New research on ketone supplements
- Updated Key Concepts
- New links to calculators that assess cardiovascular disease risk
- Updated information on low-fat diets and weight loss
- New data on the interactions between different fats, carbohydrate, and heart disease
- New Application Exercise
- New and revised references

Chapter 6—Protein: The Tissue Builder
- Update on the importance of dietary protein during weight loss
- New information on the postexercise anabolic window
- New Training Tables on protein recommendations and creatine supplementation for athletes
- New information on IOC consensus on dietary supplements that can improve performance or alter body composition
- Updated information on creatine supplementation and recovery from injury
- New data on the effects of creatine supplementation on cognitive processing, concussion, and brain health
- Updated information on the benefits of beta-alanine supplements
- New and revised references

Chapter 7—Vitamins: Fat-Soluble, Water-Soluble, and Vitamin-Like Compounds
- Relevant content on the vitamins with updates based on the most current position paper from the Academy of Nutrition and Dietetics and the American College of Sports Medicine
- Expanded overview of vitamins with a revamped table 7.1 showing a summary of each vitamin
- Updated content with the latest research on the effects of specific vitamins on health and physical activity performance
- New photos to break up the text and provide a visual of good food sources for each vitamin
- A new figure 7.5 showing the role of folate and vitamin B12 in red blood cell formation
- Two new Training Tables, one listing the classification of fat-soluble and water-soluble vitamins and vitamin-like substances, and another providing practical advice about how to read a Supplement Facts label and make prudent vitamin supplement choices
- Specific information on the health aspects of vitamin supplements now integrated within the discussion of each vitamin
- New Multiple Choice and Critical Thinking Questions
- New and revised references

Chapter 8—Minerals: The Inorganic Regulators
- Relevant content on the minerals with updates based on the most current position paper from the Academy of Nutrition and Dietetics and the American College of Sports Medicine
- Expanded overview of minerals with additional content on the difference between major, trace, and possibly essential minerals, including new tables 8.2 and 8.4 summarizing each of the major and trace minerals
- Updated content with the latest research on the effects of specific minerals on health and physical activity performance
- New photos to break up the text and provide a visual of good food sources for each mineral
- Four new Training Tables on topics including factors that increase or decrease calcium absorption, how to reduce one's risk for osteoporosis and improve bone health, common signs and symptoms of iron-deficiency anemia, and a summary of two possibly essential minerals
- New table 8.5 differentiating factors that influence iron bioavailability and an expanded section on iron-deficiency anemia
- A new Application Exercise is provided for students to evaluate minerals with potential ergogenic benefits and to develop informational handouts on one of those minerals
- New Multiple Choice and Critical Thinking Questions
- New and revised references

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Chapter 9—Water, Electrolytes, and Temperature Regulation
- Revised and updated figures and tables
- Addition of the new American Heart Association blood pressure guidelines
- Five new Training Tables covering the topics of temperature regulation and heat loss; key highlights of the ACSM position stand on exercise and fluid replacement; symptoms of hyponatremia; recommendations pertaining to fluid and carbohydrate intake before, during, and after exercise; and selected benefits of acclimatization
- New Application Exercise
- New Multiple Choice and revised Critical Thinking Questions
- New and revised references

Chapter 10—Body Weight and Composition for Health and Sport
- Modified and updated figures and tables
- Five new Training Tables covering the symptoms of the metabolic syndrome, symptoms of anorexia nervosa, *DSM-V* criteria for bulimia nervosa, behaviors associated with binge eating disorder, and other selected disordered eating or body image disorders
- New Application Exercise
- New Multiple Choice questions
- New and revised references

Chapter 11—Weight Maintenance and Loss through Proper Nutrition and Exercise
- Many new or modified figures and tables
- New Nutrition Facts label designed according to the *2015-2020 Dietary Guidelines for Americans*
- New Training Table listing suggestions to reduce overeating and increase physical activity
- New Application Exercise
- New Multiple Choice questions and revised Critical Thinking questions
- New and revised references

Chapter 12—Weight Gaining through Proper Nutrition and Exercise
- Many new and revised figures and tables
- Expanded discussion of nutrient timing
- Discussion of the proposed role of β-hydroxy-β-methylbutyrate (HMB) in increased muscle protein synthesis and decreased catabolism
- Additional text on the importance of concentric and eccentric contractions to induce muscle hypertrophy
- Expanded discussion of the importance of consistency in time of day for resistance training
- Modified Figure 12.15 to emphasize muscle fiber hypertrophy as the dominant mechanism for muscle growth
- New Table 12.4 listing selected health effects of resistance training
- Discussion of potential cell-signaling "competition" between high volume aerobic and high volume resistance training which might attenuate muscle hypertrophy
- New Application Exercise
- New Multiple Choice questions
- New and revised references

Chapter 13—Nutritional Supplements and Ergogenic Aids
- Many new and updated figures and tables
- Revised Table 13.2 to include effects of alcohol on brain function
- Table 13.3 listing selected cardiovascular diseases and symptoms that are associated with excessive alcohol consumption
- Table 13.4 listing possible effects of alcohol consumption on weight gain
- Table 13.5 listing proposed mechanisms of light-to-moderate alcohol consumption on cardiovascular health
- Table 13.7 listing effects of caffeine on selected performance tasks
- Table 13.8 listing caffeine content in selected energy drinks and shots with descriptive information on caffeine content for 408 energy drinks and 86 energy shots
- Discussion of ergogenic mechanisms of dietary nitrates
- New Application Exercise
- New Multiple Choice questions
- New and revised references

Enhanced Pedagogy

Each chapter contains several features to help enhance the learning process. **Learning Outcomes** are presented at the beginning of each chapter, highlighting the key points and serving as a studying guide for students and an assessment tool for faculty. **Key Terms** also are listed at the beginning of each chapter and definitions are included both in the chapter and in the glossary. A new Training Table feature has also been added to this edition of the textbook. The **Training Tables** emphasize practical and current concepts relevant to each chapter. **Key Concepts** provide a summary of essential information presented throughout each chapter. Bulleted lists are utilized to help students focus on the key information. **Check for Yourself** includes individual activities, such as checking food labels at the supermarket or measuring one's own body fat percentage. The **Application Exercise** at the end of each chapter may require more extensive involvement, such as a case study or a survey of an athletic team. **Multiple Choice Questions** and **Critical Thinking Questions** are also included at the end of each chapter for students to self-assess their knowledge of the chapter content. The Critical Thinking Questions require students to apply the knowledge they've learned in each chapter.

The reference lists have been completely updated for this edition with the inclusion of hundreds of new references that provide the scientific basis for the new concepts or additional support for those concepts previously developed. These references provide greater in-depth reading materials for the interested student. Although the content of this book is based on appropriate scientific studies, a reference-citation style is not used, that is, each statement is not referenced by a bibliographic source. However, names of authors may be used to highlight a reference source where deemed appropriate.

This book is designed primarily to serve as a college text in professional preparation programs in dietetics and human nutrition, health and physical education, exercise science, athletic training, sports medicine, and sports nutrition. It is also directed to the

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physically active individual interested in the nutritional aspects of physical and athletic performance.

Those who desire to initiate a physical training program may also find the nutritional information useful, as well as the guidelines for initiating a training program. This book may serve as a handy reference for coaches, trainers, and athletes. With the tremendous expansion of youth sports programs, parents may find the information valuable relative to the nutritional requirements of their active children.

In summary, the major purpose of this book is to help provide a sound knowledge base relative to the role that nutrition, complemented by exercise, may play in the enhancement of both health and sports performance. We hope the information provided in this text will help inspire the reader to make health-promoting choices related to diet and physical activity.

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This book would not be possible without the many medical/health scientists and exercise/sports scientists throughout the world who, through their numerous studies and research, have provided the scientific data that underlie its development. We are fortunate to have developed a friendship with many of you, and we extend our sincere appreciation to all of you. We would like to thank the following nutrition educators who reviewed this text.

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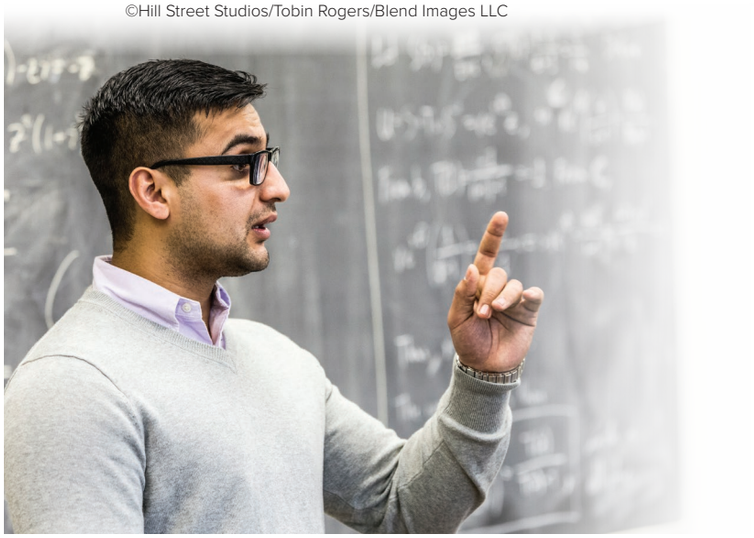

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>
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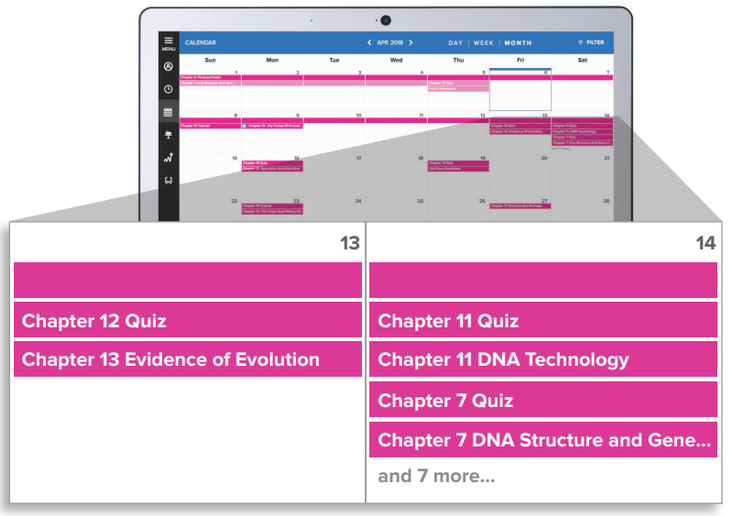

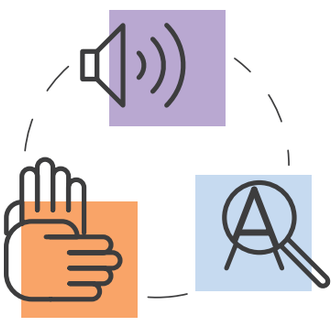

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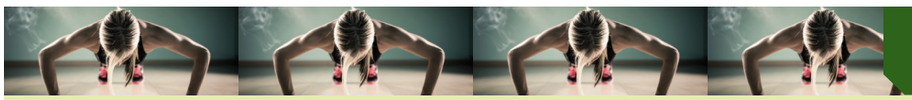
Introduction to Nutrition for Health, Fitness, and Sports Performance

KEY TERMS

antipromoters
cytokines
doping
epidemiological research
epigenetics
epigenome
ergogenic aids
exercise
experimental research
health-related fitness
high-intensity interval training (HIIT)
malnutrition
meta-analysis
nutrient
nutrition
physical activity
physical fitness
promoters
Prudent Healthy Diet
quackery
risk factor
Sedentary Death Syndrome (SeDS)
sports nutrition
sports-related fitness
sports supplements
structured physical activity
unstructured physical activity



CHAPTER ONE

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LEARNING OUTCOMES

After studying this chapter, you should be able to:

1. List the leading causes of death in the United States and identify those that may be related to lifestyle factors, including diet and/or physical activity.
2. Explain the importance of genetics, diet, and physical activity in the determination of optimal health and successful sport performance.
3. Describe the components of health-related fitness and identify the potential health benefits associated with each.
4. Compare and contrast sports-related fitness and health-related fitness.
5. Summarize the seven key principles of exercise training.
6. Explain the importance of diet choices and proper nutrition in promoting optimal health and wellness.
7. Summarize the role of dietary supplements as ergogenic aids to promote sports performance.
8. Define nutritional quackery and provide strategies that can be utilized to determine whether claims regarding a dietary supplement are valid.
9. Explain what types of research have been used to evaluate the relationship between nutrition and health or sport performance, and evaluate the pros and cons of each type.

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Introduction

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There are two major focal points of this book. One is the role that nutrition, complemented by physical activity and exercise, may play in the enhancement of one's health status. The other is the role that nutrition may play in the promotion of fitness and sports performance. Many individuals today are physically active, and athletic competition spans all ages. Healthful nutrition is important throughout the life span of the physically active individual because suboptimal health status may impair training and competitive performance. In general, as we shall see, the diet that is optimal for health is also optimal for exercise and sports performance.

Nutrition, fitness, and health. Health care in most developed countries has improved tremendously over the past century. With modern health care, once deadly diseases are no longer a major source of concern. Rather, the treatment and prevention of chronic diseases, such as diabetes and obesity, are now the emphasis of much research and health recommendations.

Table 1.1 lists the ten leading causes of death in the United States in 2015 and the approximate percentage of deaths associated with each. For both males and females, heart disease is the leading cause of death, accounting for death in nearly one in four Americans. Of the leading causes of death, risk for heart disease, cancer, stroke, Alzheimer's disease, diabetes, and kidney disease have been linked to a person's diet and physical activity habits. According to the U.S. Department of Health and Human Services (HHS), unhealthy eating and physical inactivity are primary contributors to death in the United States.

TABLE 1.1 Leading causes of death in the United States (2015)

	Approximate percentage of deaths
Heart disease*	23.4
Cancer*	22.0
Chronic lower respiratory infections	5.7
Unintentional injuries (accidents)	5.4
Stroke*	5.2
Alzheimer's disease*	4.1
Diabetes mellitus*	2.9
Influenza and pneumonia	2.1
Kidney disease*	1.8
Suicide	1.6
All other causes	25.8

*Cause of death for which diet and/or physical activity may impact risk.

Source: National Center for Health Statistics: *Health, United States, 2015*. www.cdc.gov/nchs/fastats/deaths.htm. Accessed: February 15, 2018.

In addition to lifestyle choices, family history also impacts risk for chronic disease. According to Simopoulos, all diseases have a genetic predisposition. The Human Genome Project, which deciphered the DNA code of our 80,000 to 100,000 genes, has identified various genes associated with many chronic diseases, such as breast and prostate cancer. Genetically, females whose mothers had breast cancer are at an increased risk for breast cancer, while males whose fathers had prostate cancer are at an increased risk for prostate cancer.

Completion of the Human Genome Project is believed to be one of the most significant medical advances of all time. Although multiple genes are involved in the etiology of most chronic diseases

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and research regarding the application of the findings of the Human Genome Project to improve health is still in its initial stages, the future looks bright. For individuals with genetic profiles predisposing them to a specific chronic disease, such as cancer, genetic therapy eventually may provide an effective treatment or cure.

Our genes harbor many secrets to a long and healthy life, but genes alone are unlikely to explain all the secrets of longevity. The role of a healthful diet and exercise are intertwined with your genetic profile. What you eat and how you exercise may influence your genes. **Epigenetics** is a relatively new field of research involving the role of the **epigenome,** a multitude of specialized chemical compounds that influence the human genome by activating or deactivating DNA and subsequent genetic and cellular activity. Various factors in our environment, such as substances in the foods we eat, may interact with the epigenome and thus modify cell functions—either in a positive or negative manner. Exercise, as noted later, also stimulates release of substances from muscle cells that may affect the epigenome. Genomics represents the study of genetic material in body cells, and the terms *nutrigenomics* and *exercisenomics* have been coined to identify the study of the genetic aspects of nutrition and exercise, respectively, as related to health benefits. *Sportomics* involves study of the metabolic response of the athlete in an actual sport environment, not in a laboratory.

Preventing chronic disease. Many forms of chronic disease are preventable through proper nutrition and physical activity and recognizing risk factors for a particular health condition. A **risk factor** is a lifestyle behavior that has been associated with a particular disease, such as cigarette smoking being linked to lung cancer. As described previously, diet and physical activity choices are also key risk factors for chronic disease. For example, a sedentary lifestyle and being overweight are risk factors for heart disease and some forms of diabetes.

To help improve the health of Americans, the United States Office of Disease Prevention and Health Promotion (ODPHP) publishes health-related reports and goals every ten years. Many of the goals outlined in *Healthy People 2020* address issues specific to physical activity and diet choices. The *Training Table* in this section provides examples of objectives related to physical activity. Experts began planning for *Healthy People 2030* at a national meeting in September 2017.

Nutrition, fitness, and sport. *Sport* is most commonly defined as a competitive athletic activity requiring skill or physical prowess, for example, baseball, basketball, soccer, football, track, wrestling, tennis, and golf.

Training Table

Examples of some of the ***Healthy People 2020*** objectives related to physical activity:

- Reduce proportion of adults who engage in no leisure-time physical activity.
- Increase the proportion of adults/adolescents who meet current federal physical activity guidelines for aerobic and muscular-strengthening activities.
- Increase the proportion of the nation's public and private schools that require daily physical education for all students.
- Increase regularly scheduled elementary school recess in the United States.
- Increase the proportion of trips made by walking/bicycling.

Visit www.healthypeople.gov to see how progress is being made toward these goals.

To be successful at high levels of competition, athletes must possess the appropriate biomechanical, physiological, and psychological genetic characteristics associated with success in a given sport. International-class athletes have such genetic traits. In recent reviews, Tucker and others highlighted the genetic basis for elite running performance while Eynon and others discussed the role of genes for elite power and sprint performance. Moreover, Wolfarth and others have assembled a human gene map for performance and health-related fitness.

For optimal performance, athletes must also develop their genetic characteristics maximally through proper biomechanical, physiological, and psychological coaching and training. Whatever the future holds for genetic enhancement of athletic performance, specialized exercise training will still be the key to maximizing genetic potential for a given sport activity. Training programs at the elite level have become more intense and individualized, sometimes based on genetic predispositions. Modern scientific training results in significant performance gains, and world records continue to improve. David Epstein, in his book *The Sports Gene,* provides a fascinating account of the role both genes and the training environment play relative to elite sport performance.

Proper nutrition is also an important component in the total training program of the athlete. Certain nutrient deficiencies can seriously impair performance, whereas supplementation of other nutrients may help delay fatigue and improve performance. Over the past 50 years, research has provided us with many answers about the role of nutrition in athletic performance, yet there is still much to be learned as research in sports nutrition continues to expand.

The purpose of this chapter is to provide a broad overview of the role that exercise and nutrition may play relative to health, fitness, and sport, and to provide evidence-based recommendations. More detailed information regarding specific relationships of nutritional practices to health and sports performance is provided in subsequent chapters.

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www.health.gov/healthypeople Check for the full report of *Healthy People 2020*.

www.who.int/dietphysicalactivity/en/ The World Health Organization report provides global recommendations related to diet and physical activity for health.

www.ncbi.nlm.nih.gov/genome/guide/human/ Access the human genome map and the National Institutes of Health Epigenetics Roadmap.

Key Concepts

- Many chronic diseases in major developed countries (heart disease, cancer, stroke, and diabetes) may be prevented by appropriate lifestyle behaviors, particularly maintaining a healthy body weight, proper exercise and a healthy diet.
- The two primary determinants of health status are genetics and lifestyle.
- Several of the key health promotion objectives in *Healthy People 2020* are increased levels of physical activity, a healthier diet, and reduced levels of overweight and obesity.
- Sports success is dependent on biomechanical, physiological, and psychological characteristics specific to a given sport, but proper training, including nutrition, is essential to maximizing one's genetic potential.

Check for Yourself

- Discuss with your parents, grandparents, and other relatives any health problems they have experienced, such as high blood pressure or diabetes, to determine whether you may be predisposed to such health problems in the future. Use the "My Family Health Portrait" tool at https://familyhistory.hhs.gov/FHH/html/index.html to create a family health history.

Fitness and Exercise

Physical fitness may be defined, in general terms, as a set of abilities individuals possess to perform specific types of physical activity. The development of physical fitness is an important concern of many professional health organizations, including the Society of Health and Physical Educators (SHAPE), which has classified fitness components into two different categories. In general, these two categories may be referred to as health-related fitness and sports-related fitness. Both types of fitness may be influenced by nutrition and exercise.

How are health-related fitness and sports-related fitness different?

As summarized in the introduction to this chapter, lifestyle behaviors, including appropriate physical activity and a high-quality diet, may influence one's health status and wellness. Proper physical activity may improve one's health status by helping to prevent excessive weight gain, but it may also enhance other facets of health-related fitness as well. **Health-related fitness** includes not only a healthy body weight and body composition, but also cardiovascular-respiratory fitness, adequate muscular strength and muscular endurance, and sufficient flexibility (**figure 1.1**). As one ages, other measures used as markers of health-related fitness include blood pressure, bone strength, postural control and balance, and various indicators of lipid and carbohydrate metabolism.

In contrast to health-related fitness, **sports-related fitness** is the fitness an athlete develops specific to their sport. Dependent on the sport, this may include strength, power, speed, endurance, and/or neuromuscular motor skills. Through proper physical and mental training, athletes may maximize their genetic potential, thus preparing both their body and mind for intense competition. Compared to health-related fitness, training for sports performance is often more intense, prolonged, and frequent than training for health.

What are the basic principles of exercise training?

Several health professional organizations, such as the American College of Sports Medicine (ACSM) and American Heart Association (AHA), have indicated that various forms of physical activity may be used to enhance health. In general, **physical activity** involves any bodily movement caused by muscular contraction that results in the expenditure of energy. For the purpose of studying its effects on health, some epidemiologists classify physical activity as either unstructured or structured.


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Unstructured physical activity, also known as leisure-time activity, includes many of the usual activities of daily living, such as leisurely walking and cycling, climbing stairs, dancing, gardening and yard work, various domestic and occupational activities, and games and other childhood pursuits. These unstructured activities are not normally planned to be exercise. However, as will be noted throughout the textbook, these types of activities may play an important role in body weight control.

Structured physical activity, as the name implies, is a planned program of physical activities usually designed to improve fitness. For the purpose of this book, we shall refer to structured physical activity as **exercise,** particularly some form of planned moderate or vigorous exercise, such as brisk, not leisurely, walking.

Exercise training programs may be designed to provide health-related and/or sports-related fitness benefits. However, no matter what the purpose, several general principles are used in developing an appropriate exercise training program.

Principle of Overload Overload is the basic principle of exercise training, and it represents the altering of the intensity, duration, and frequency of exercise. For example, a running program for cardiovascular-respiratory fitness could involve training at an intensity of 70 percent of maximal heart rate, a duration of 30 minutes, and a frequency of 5 times per week. The adaptations the body makes are based primarily on the specific exercise overload.

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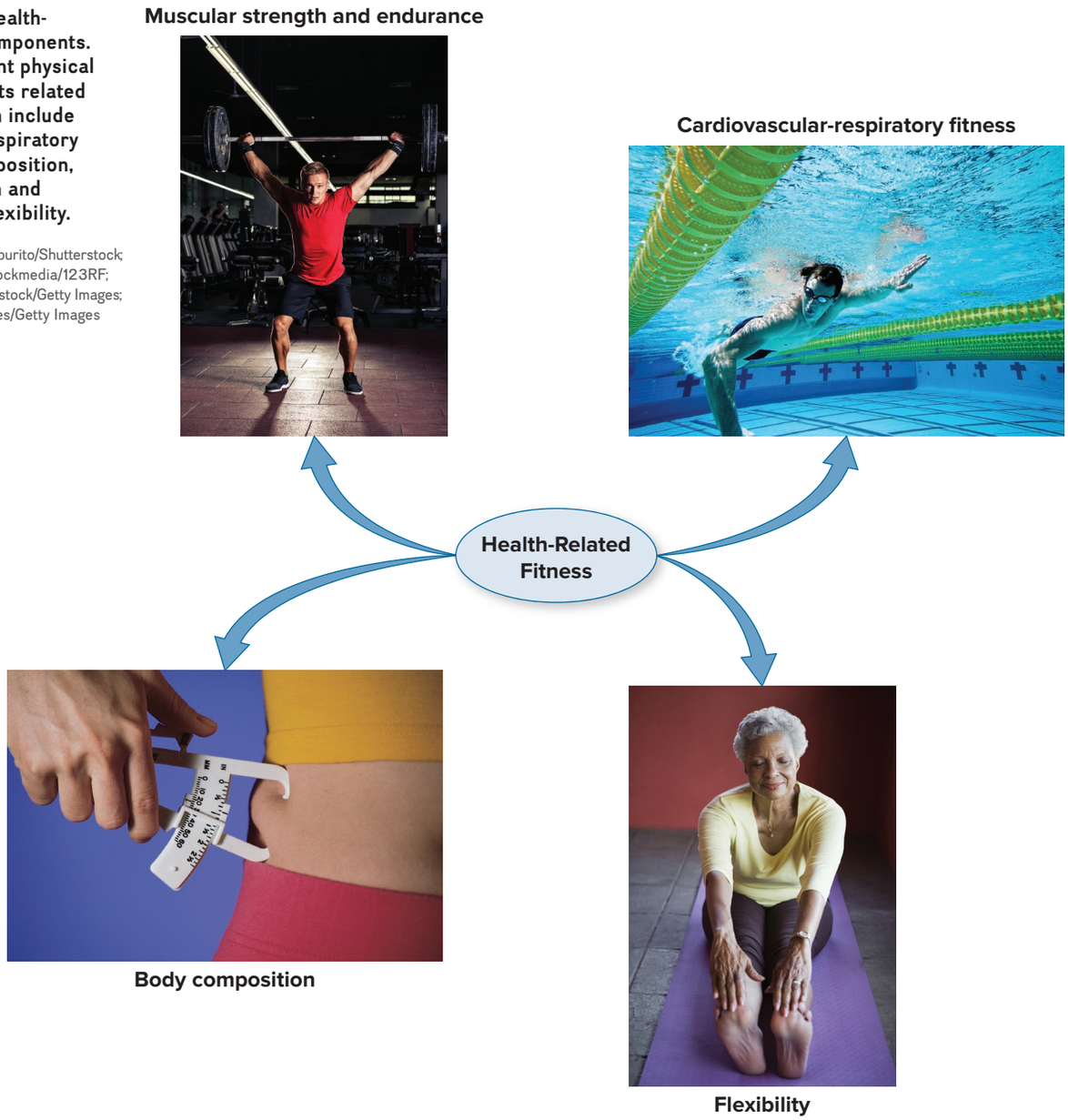

FIGURE 1.1 **Health-related fitness components. The most important physical fitness components related to personal health include cardiovascular-respiratory fitness, body composition, muscular strength and endurance, and flexibility.**

Muscular strength: ©takoburito/Shutterstock; Cardiovascular: ©epicstockmedia/123RF; Body composition: ©Comstock/Getty Images; Flexibility: ©Jupiterimages/Getty Images

The terms *moderate* exercise and *vigorous* exercise are often used to quantify exercise intensity and are discussed later in this chapter.

Principle of Progression Progression is an extension of the overload principle. As your body adapts to the original overload, the overload must be increased if further beneficial adaptations are desired. For example, you may start lifting a weight of 20 pounds, increase the weight to 25 pounds as you get stronger, and so forth. The overloads are progressively increased until the final health-related or sports-related goal is achieved or exercise limits are reached.

Principle of Specificity Specificity of training represents the specific adaptations the body will make in response to the type of exercise and overload. For example, running and weight lifting impose different demands on muscle energy systems, so the body adapts accordingly. Both types of exercise may provide substantial, yet different, health benefits. Exercise training programs may be designed specifically for certain health or sports-performance benefits.

Principle of Recuperation Recuperation is an important principle of exercise training. Also known as the principle of recovery, it represents the time in which the body rests after exercise. This principle may apply within a specific exercise period, such as including rest periods when doing multiple sets during a weight-lifting workout. It may also apply to rest periods between bouts of exercise, such as a day of recovery between two long cardiovascular workouts.

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Principle of Individuality Individuality reflects the effect exercise training will have on each individual, as determined by genetic characteristics. The health benefits one receives from a specific exercise training program may vary tremendously among individuals. For example, although most individuals with high blood pressure may experience a reduction during a cardiovascular-respiratory fitness training program, some may not.

Principle of Reversibility Reversibility is also referred to as the principle of disuse, or the concept of *use it or lose it.* Without the use of exercise, the body will begin to lose the adaptations it has made over the course of the exercise program. Individuals who suffer a lapse in their exercise program, such as a week or so, may lose only a small amount of health-related fitness gains. However, a total relapse to a previous sedentary lifestyle can reverse all health-related fitness gains.

Principle of Overuse Overuse represents an excessive amount of exercise that may induce some adverse, rather than beneficial, health effects. Overuse may be a problem during the beginning stages of an exercise program if one becomes overenthusiastic and exceeds her capacity, such as developing shin splints by running too much or too far. As described in chapter 3, overuse may also occur in elite athletes who become overtrained.

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FIGURE 1.2 Exercise is medicine. Researchers have identified more than three dozen specific health benefits associated with engaging in regular physical activity. This figure summarizes some of those key health benefits.

Exercise and Health Promotion

The beneficial effect of exercise on health has been known for centuries. For example, Plato noted that "lack of activity destroys the good condition of every human being while movement and methodical physical exercise save and preserve it." Plato's observation is even more relevant in contemporary society. Frank Booth, a prominent exercise scientist at the University of Missouri, has coined the term **Sedentary Death Syndrome,** or **SeDS,** and he and his colleagues have noted that physical inactivity is a primary cause of most chronic diseases. Slentz and others discussed the cost of physical inactivity over time. The *short-term* cost of physical inactivity is metabolic deterioration and weight gain; the *intermediate-term* cost is an increased risk for disease, such as type 2 diabetes, whereas the *long-term* cost is increased risk for premature mortality.

To help promote the health benefits of physical activity, the ACSM and the American Medical Association (AMA) launched a program, entitled *Exercise Is Medicine*™, designed to encourage physicians and other health-care professionals to include exercise as part of the treatment for every patient. Clinical, epidemiological, and basic research evidence clearly supports the inclusion of regular physical activity as a tool for the prevention of chronic disease and the enhancement of overall health. **Figure 1.2** summarizes some of the specific health benefits that have been associated with regular physical activity.

In essence, physically active individuals enjoy a higher quality of life, a *joie de vivre,* because they are less likely to suffer the disabling symptoms often associated with chronic diseases, such as loss of ambulation experienced by some stroke victims. As noted in the next section, physical activity may also increase the quantity of life. James Fries, who studied healthy aging at the Stanford University School of Medicine's Center on Longevity, stated, "If you had to pick one thing to make people healthier as they age, it would be aerobic exercise."

How does exercise enhance health?

The specific mechanisms whereby exercise may help to prevent the development of various chronic diseases are not completely understood. However, such benefits are likely related to changes in gene expression that modify cell structure and function following physical activity. As noted previously, research by Booth and Neufer found that physical inactivity causes genes to misexpress proteins, producing the metabolic dysfunctions that result

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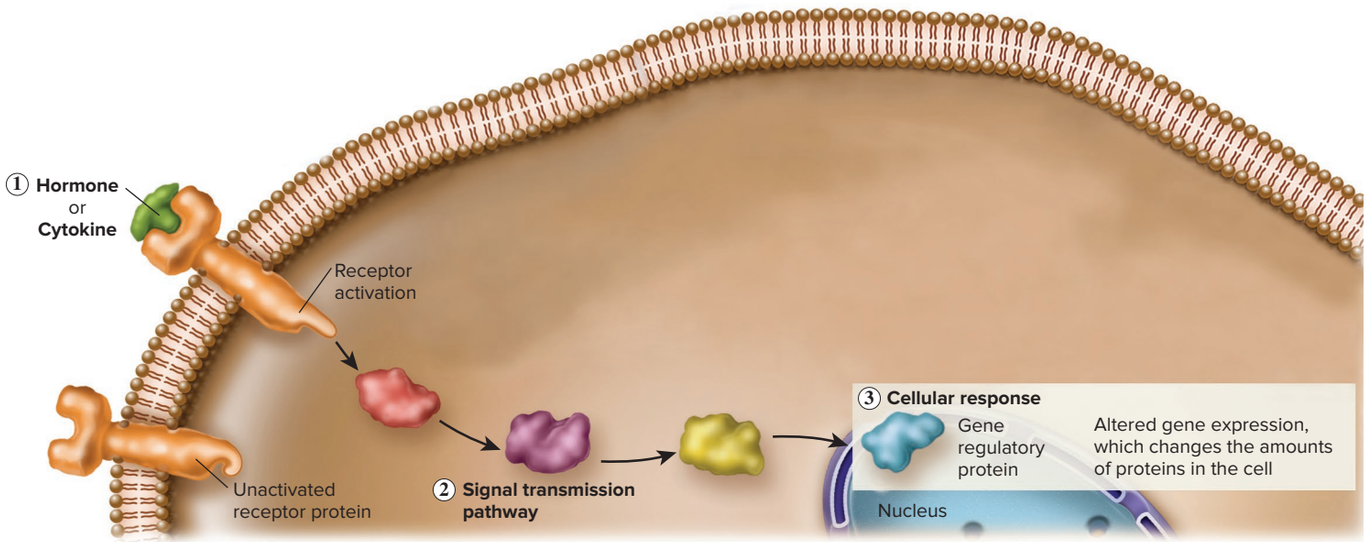

FIGURE 1.3 Exercise may induce adaptations that have favorable health effects in various body tissues. One suggested mechanism is the effect that various hormones or cytokines, which are produced during exercise, may have on gene regulation in body cells. (1) The hormone or cytokine binds to a cell receptor that activates a signal within the cell, (2) the signal is transmitted along a specific pathway, (3) the signal may alter gene expression and induce changes within the cell. Cell signals may also affect enzymes or other cell structures that may induce beneficial health effects.

in overt clinical disease if continued long enough. In contrast, exercise may cause the expression of genes with favorable health effects.

Most body cells can produce and secrete small proteins known as **cytokines,** which are similar to hormones and can affect tissues throughout the body. Cytokines enter various body tissues, influencing gene expression that may induce adaptations either favorable or unfavorable to health (**figure 1.3**). Two types of cytokines are of interest to us. Muscle cells produce various cytokines called *myokines* (referred to as *exerkines* when produced during exercise), whereas fat (adipose) cells produce cytokines called *adipokines.* Muscle cells also produce *heat shock proteins (HSPs),* which may have beneficial health effects. **Table 1.2** lists important cytokines produced in muscle and fat cells.

Overall, Brandt and Pederson theorize that exercise-induced cytokine effects on genes reduce many of the traditional risk factors associated with development of chronic diseases; Geiger and others note similar effects for HSPs. According to McAtee, one of the common causes of various chronic diseases is an inflammatory environment created by the presence of excess fat, particularly within blood vessels. Local inflammation is thought to promote the development of several types of chronic disease, including heart disease, cancer, diabetes, and dementia. Work by Nimmo and others suggests that exercise produces an anti-inflammatory cytokine that may help cool inflammation and reduce such health risks. They note that the most marked improvements in the inflammatory profile are conferred with exercise performed at higher intensities, with combined aerobic and resistance exercise training potentially providing the greatest benefit. Cytokines and heat shock proteins may also prevent chronic diseases by increasing the number of glucose receptors in muscle cells, improving insulin sensitivity, and helping to regulate blood glucose and prevent type 2 diabetes.

TABLE 1.2 Major cytokines produced in muscle and fat cells

Muscle cells	Fat cells
Interleukin-6 (IL-6)	Tumor Necrosis Factor-alpha (TNF-α)
Brain-Derived Neurotropic Factor (BDNF)	Adiponectin

There are also other health-promoting mechanisms of exercise. One of the most significant contributors to health problems with aging is sarcopenia, or loss of muscle tissue. In their review, Landi and others conclude that regular exercise is the only strategy found to consistently prevent frailty and improve sarcopenia and physical function in older adults. Additional mechanisms associated with exercising lowering risk for chronic disease include:

- Loss of excess body fat may reduce production of cytokines that may impair health.
- Loss of excess body fat may reduce estrogen levels, reducing risk of breast cancer.
- Reduction of abdominal obesity may decrease blood pressure and serum lipid levels.
- Increased mechanical stress on bone with high-impact exercise may stimulate increases in bone density.
- Production of some cytokines, such as BDNF, may enhance neurogenesis and brain function.

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Some healthful adaptations may occur with even just a single bout of exercise. Nimmo and others reported that single bouts of exercise have a potent anti-inflammatory influence, while others have noted that a single exercise session can acutely improve the blood lipid profile, reduce blood pressure, and improve insulin sensitivity, all beneficial responses. However, such adaptations will regress unless exercise becomes habitual. Thus, to maximize health benefits, exercise should be done most days of the week. The role that exercise may play in the prevention of some chronic diseases, such as heart disease and diabetes, and associated risk factors, such as obesity, are discussed throughout this book where relevant.

Physical Activity Guidelines

Physical activity guidelines for Americans are developed by the U.S. Department of Health and Human Services (HHS) through collaborative efforts with the Office of Disease Prevention and Health Promotion (ODPHP), Centers for Disease Control and Prevention (CDC), National Institutes of Health (NIH), and the President's Council on Fitness, Sports, and Nutrition (PCFSN). The *Training Table* in this section summarizes the key physical activity guidelines for healthy adults from the *2008 Physical Activity Guidelines for Americans*. Updated physical activity guidelines are expected to be released in 2018. You can learn more about the process of developing the 2018 physical activity guidelines and follow the latest on these recommendations at https://health.gov/paguidelines/.

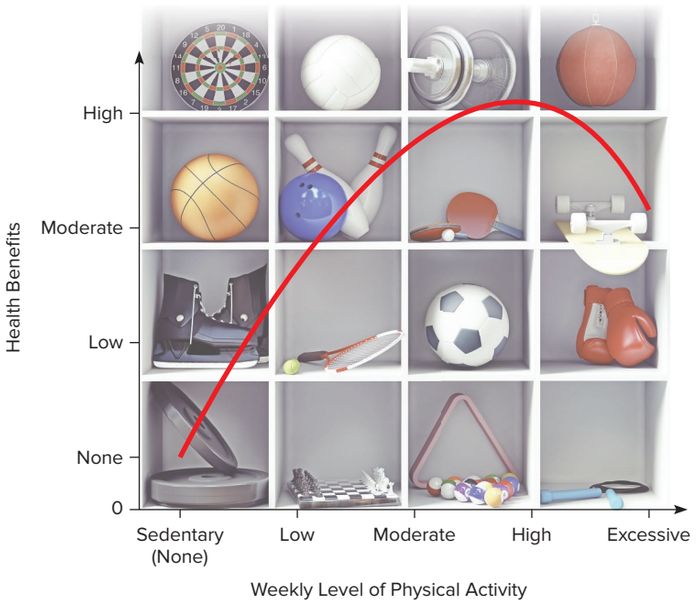

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FIGURE 1.4 Significant health benefits may occur at low to moderate levels of physical activity with diminishing returns as the amount of exercise becomes excessive. Dependent on the individual, exercising too much or, in some cases, at an excessive intensity, may actually be detrimental to health.

Training Table

According to the *2008 Physical Activity Guidelines for Americans*, healthy adults should avoid inactivity. For optimal health benefits, healthy adults should:

- Participate in at least 150 minutes (2 hours and 30 minutes) a week of moderate-intensity physical activity or 75 minutes (1 hour and 15 minutes) a week of vigorous-intensity physical activity. Aerobic activity should be spread out throughout the week.
- Participate in muscle-strengthening activities, such as lifting weights or using resistance bands, that are moderate- or high-intensity and involve all major muscle groups at least two days a week.
- Include flexibility exercises, such as stretching, yoga, or Pilates, as part of the exercise program. Time spent doing such activities should not be counted toward meeting the aerobic- or muscle-strengthening guidelines, but such flexibility exercises may reduce risk for injury and support optimal health and aging.

Visit https://health.gov/paguidelines/ for a complete list of the physical activity guidelines, including those specific for active children and adolescents as well as for older adults.

Key principles for developing physical activity programs

To reap the health benefits of exercise, most health professionals recommend a comprehensive program of physical activity, including aerobic exercise and resistance training. Flexibility and balance exercises become increasingly important for older adults to prevent falls and maintain mobility as one ages. In general, there is a curvilinear relationship between the amount of physical activity (dose) and related health benefits (response). As shown in **figure 1.4,** a sedentary lifestyle is thought to offer no health benefits. However, health benefits increase rapidly with low to moderate levels of weekly activity. When a person goes beyond moderate levels of weekly physical activity, the increase in health benefits will rise gradually and then plateau. Excessive exercise may actually begin to have adverse effects on some health conditions, including unhealthy weight loss. For this reason, engaging in enough, but not too much, exercise appears to be optimal for promoting health.

The following guidelines should be considered when developing physical activity plans to promote health and wellness:

- *Individualization.* Exercise programs should be individualized based on physical fitness level and health status. Claude Bouchard, an expert in genetics, exercise, and health, noted that due to genes, physical activity may benefit some, but not others. For example, although most sedentary individuals will respond

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favorably to an aerobic exercise training program, such as an improved insulin sensitivity, others will not respond and have no change in insulin sensitivity. Currently, there is no gene profile for responders and nonresponders to exercise training, but that may change in the future so that specific exercise programs may be designed for individuals.

- *Leisure-time activity.* A key component of a fitness plan is simply to reduce the amount of daily sedentary activity. One important modification to your daily lifestyle is to sit less and move more. The *Training Table* in this section provides recommendations for building light physical activity into your daily schedule. Accumulating more daily unstructured physical activity may be very helpful in maintaining a healthy body weight. Additionally, leisurely walking may be adequate physical activity for elderly individuals with compromised health status or very low fitness levels.

Training Table

Time spent on sedentary activities, such as sitting at the computer or driving, should be limited as much as is reasonably possible. As a college student, you may spend many hours sitting in class or working on online assignments. When possible, try to get up and stretch and move around for short breaks. Additional recommendations for light activity include:

- If possible where you live, bike or walk to campus or work, rather than driving.
- Use cleaning your dorm room/suite, apartment, or house as an opportunity to get some exercise.
- Stand instead of sitting when you can.
- Take the stairs instead of the elevator.
- When driving to the supermarket or mall, park at the edge of the parking lot so you can get in more steps walking.
- Walk your dog instead of letting him or her out into the backyard (your dog needs exercise too).
- Play ultimate Frisbee, disc golf, or another similar activity with your friends.

- *Aerobic exercise.* For important health benefits, both adults and older adults should engage in moderate-intensity aerobic (endurance) exercise, such as brisk walking, for a minimum of 150 minutes every week, or about 30 minutes for 5 days. Alternatively, both may engage in vigorous-intensity exercise, such as jogging or running, for 75 minutes every week. **High-intensity interval training (HIIT)** is used to describe protocols in which the training stimulus is "near maximal" or the target intensity is between 80 and 100 percent of maximal heart rate. Comparatively, *sprint interval training (SIT)* describes protocols that involve supramaximal efforts, in which target intensities correspond to workloads greater than what is required to elicit 100 percent of maximal oxygen uptake (VO_2 max). These supramaximal exercise tasks may be accomplished in much less time as compared to moderate-intensity exercise. Additionally, adults may engage in an equivalent mix of moderate- and vigorous-intensity exercise over the course of the week.

Children and adolescents should do 60 minutes of moderate-to-vigorous physical activity daily. Short bursts of vigorous activity in games are included. Exergames, interactive video games that promote physical activity, may hold promise to promote aerobic physical activity in youth.

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Health benefits may be achieved whether the daily minute allotment for exercise is done continuously, or as three 10-minute *exercise snacks* done throughout the day, such as three brisk walks. Aerobic exercise programs, including the determination of moderate- and vigorous-intensity exercise and discussion of HIIT, are detailed in chapters 3 and 11. In brief, exercise intensity is based on the MET, a term associated with the metabolic rate that will be explained in detail in chapter 3. Your resting metabolic rate, such as when you are sitting quietly, is 1 MET. Moderate-intensity exercise is about 3–6 METs, and vigorous-intensity exercise is greater than 6 METs. You may access the MET values for a wide variety of physical activities at the following website.

https://sites.google.com/site/compendiumofphysicalactivities/. Click on Activity Categories, such as bicycling, and the METs value will be provided for a wide variety of bicycling activities.

Table 1.3 provides examples of moderate- and vigorous-intensity exercise. You might also use the "talk test" when exercising to determine your level of exercise intensity. For the present, the following characteristics of the *talk test* while exercising may be may sufficient to determine exercise intensity.

Light: You can carry on a normal conversation.
Moderate: You can talk, but not sing but a few notes before taking a breath.
Vigorous: You cannot say more than a few words.

- *Muscle-strengthening exercise.* Resistance exercise also conveys significant health benefits. Both adults and older adults should engage in muscle-strengthening activities on 2 or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders, and arms). Children and adolescents should do the same at least 3 days a week. The recommendation includes about 8 to 10 exercises that stress these major muscle groups. Individuals should perform about 8 to 12 repetitions of each exercise at least twice a week on nonconsecutive days. Older adults may lift lighter

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TABLE 1.3 Some examples of moderate-intensity and vigorous-intensity exercise

Moderate-intensity exercise	Vigorous-intensity exercise
Leisurely bicycling, 5–8 mph	Bicycling, 12 mph and faster
Walking, leisurely, 3–4 mph	Walking, 4.5 mph and faster
Dancing, slow ballroom	Dancing, aerobic, with 6- to 8-inch step
Jogging, slow on a mini-tramp	Jogging/running, 4 mph and faster
Swimming, slow leisurely	Swimming, fast crawl, 50 yards/minute
Tennis, doubles	Tennis, singles
Golf, walking, carrying clubs	Basketball, competitive game
Pilates, general	Exergaming, vigorous effort


©Assembly/Getty Images

weights or use less resistance, but do more repetitions. Resistance exercises may include use of weights or other resistance modes or weight-bearing activities such as stair climbing, push-ups, pull-ups, and various other calisthenics that stress major muscle groups. Resistance exercise programs will be discussed in chapter 12.

- *Flexibility and balance exercises.* Older adults should perform activities that help maintain or increase flexibility on at least 2 days each week for at least 10 minutes. Flexibility exercises are designed to maintain the range of joint motion for daily activities and physical activity. Older adults should also perform exercises that help maintain or improve balance about 3 times a week. Such exercises may help reduce the risk of injury from falls. Appropriate exercises are presented in the National Institute on Aging program, Go4Life. Visit https://go4life.nia.nih.gov for more information and resources for older adults.
- *A little extra may be beneficial.* The *2008 Physical Activity Guidelines for Americans* notes that more exercise time, particularly increasing the weekly amount of moderate-intensity aerobic activity to 300 minutes or vigorous-intensity aerobic activity to 150 minutes, or an equivalent combination of the two, equals more health benefits. The *Guidelines* also note that going beyond this 300 or 150 minutes a week may provide even more health benefits. A *Consumer Reports on Health* article provided a summary of an analysis of studies involving 655,000 adults. Moderate physical activity for 75 minutes a week, such as brisk walking, was linked to an additional 1.8 years of life expectancy. Those who were active at least 450 minutes (7.5 hours) a week added 4.5 years.

For those who have the time and energy, exceeding the recommended amounts of physical activity may provide additional health benefits. In particular, as noted previously, more exercise may be an important consideration to promote weight loss and prevent weight gain, a major factor in promoting health. However, as shown in **figure 1.4,** more is not always better and care should be taken not to exercise excessively.

www.health.gov/paguidelines Provides details on the Physical Activity Guidelines for children, adults, and older adults.

www.shapeamerica.org The Society for Health and Physical Educators provides physical activity guidelines for children.

www.cdc.gov/physicalactivity/everyone/guidelines/adults.html Provides details on complete exercise programs for adults.

www.who.int/dietphysicalactivity/pa/en/ The World Health Organization provides recommendations on diet and physical activity to promote health.

www.fitness.gov/be-active/ The President's Council on Sports, Fitness & Nutrition provides ideas to help you become more physically active.

www.cdc.gov/physicalactivity/basics/measuring/ This video provides information on exercise intensity.

Are Americans meeting physical activity guidelines?

According to the CDC, only 1 in 5 adults meets the recommendations of the *2008 Physical Activity Guidelines*. Compared to those living in the West, Northeast, and Midwest regions of the country, those living in the South are less likely to be physically active. As well, non-Hispanic white adults are more likely to meet the recommendations than non-Hispanic black adults and Hispanic adults. **Figure 1.5** provides a map showing physical inactivity at the state-level across the United States. Use the interactive map at https://www.cdc.gov/physicalactivity/data/databases.htm to look up the physical activity characteristics for your state or county.

Am I exercising enough?

Several approaches may be used to answer this question. One approach is to track all your physical activity for a week, such as how many minutes you walk; engage in some type of aerobic physical activity such as swimming, cycling, or jogging; or perform resistance exercise such as lifting weights. Tallying your totals for the week and comparing them to the previously mentioned recommendations for aerobic and resistance exercise will give you a good idea as to whether you are meeting current recommendations.

Today, there are a plethora of exercise gadgets that can be used to monitor and record your daily levels of physical activity. Such gadgets started with the basic pedometer, but now include numerous gadgets you can wear on your wrist or put in your pocket that will effortlessly synchronize with your smartphone and provide you data on heart rate, blood pressure, energy (kcal) expended, and other health-related variables. **Figure 1.6** provides examples of fitness trackers useful for monitoring and tracking physical activity. The cost varies, and the fitness tracker business continues to expand with new products on the market.

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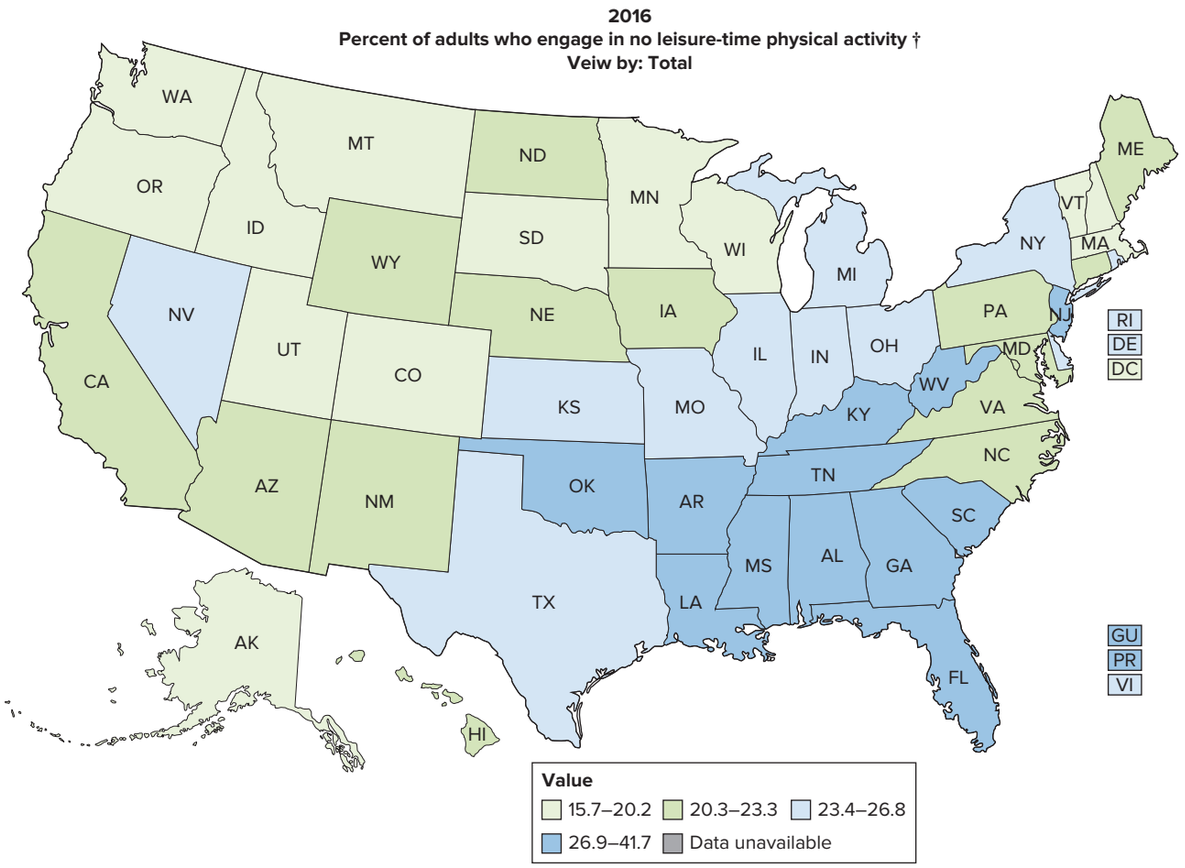

FIGURE 1.5 This map of the United States (2016) shows the percentage of the population who are physically inactive. The darker the color indicates a greater proportion of those living in that area who do not engage in regular physical activity.

Source: CDC

Pedometer: ©andreypopov/123RF; Fitness band: ©Sasils/Shuttestock; Smart watch: ©Alexey Boldin/Shutterstock; Heart rate monitor: ©suedhang/Getty Images

FIGURE 1.6 There are numerous gadgets available to track physical activity and/or heart rate during exercise.

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Can too much exercise be harmful to my health?

In general, the health benefits far outweigh the risks of exercise. Although individuals training for sport may need to undergo prolonged, intense exercise training, such is not the case for those seeking health benefits of exercise. Given our current state of knowledge, adhering to the guidelines presented above, preferably at the upper time and day limits, should be safe and provide optimal health benefits associated with physical activity. However, exercise, particularly when excessive and in individuals with preexisting health problems, may increase health risks. Training for and participating in various sports may also predispose one to various health problems.

- *Orthopedic problems.* Too much exercise may lead to orthopedic problems, such as stress fractures in the lower leg in those who run, particularly in those with poor biomechanics. Injuries to tendons and bones are common in some sports. Proper rest is often recommended for such injuries.
- *Impaired immune functions.* While moderate physical activity may enhance immune function, prolonged, high-intensity exercise temporarily impairs immune competence, which may be associated with an increased incidence of upper respiratory tract infections. Moreover, according to a recent review by Nijs and others, individuals with chronic fatigue syndrome may have an altered immune response to exercise and other reports link it to excessive exercise.
- *Exercise-induced asthma.* Some endurance athletes, such as runners and cross-country skiers, particularly when exercising in cold weather, may be more prone to exercise-induced asthma. Excessive lung ventilation may dry the airways with subsequent release of inflammatory mediators that cause contraction of the airways, making breathing more difficult. In severe cases, exercise-induced asthma may be fatal.
- *Exercise addiction.* Exercise is known to release various brain chemicals, including endorphins, which may elicit euphoric feelings such as the *runners high.* However, experts note that exercise addiction may also have an obsessive-compulsive dimension and may be linked to other psychiatric disorders, such as substance abuse and eating disorders.
- *Osteoporosis.* When coupled with inadequate dietary energy intake, exercise that leads to excessive weight loss may contribute to the menstrual irregularities in female athletes that may exacerbate loss of bone mass, or osteoporosis. Known as the female athlete triad, this topic is discussed in chapters 8 and 10.
- *Heat illness and kidney failure.* Exercising in the heat may cause heat stroke or other heat illnesses with serious consequences, such as kidney failure and death, as discussed in chapter 9.
- *Brain damage.* As noted previously, exercise exerts multiple beneficial effects on the brain, such as improved psychological health and reduced risk of mental decline with aging. However, participation in some sports may be associated with mild traumatic brain injury (mTBI) and, rarely, catastrophic traumatic injury and death. Repetitive mTBIs, such as concussions, can lead to neurodegeneration, or chronic traumatic encephalopathy (CTE). CTE has been reported most frequently in American football players and boxers but is also associated with other sports such as ice hockey, soccer, rugby, and baseball.
- *Heart attacks and sudden death.* Although sudden death among young athletes is very rare, it is still two to three times more frequent than in the age-matched control population and attracts significant media attention.

  Sudden death in older athletic individuals may be associated with coronary artery disease, discussed in detail in chapter 5. In brief, atherosclerosis in the heart's blood vessels may limit oxygen supply to the heart muscle, triggering what is known as an ischemic heart attack. Experts recommend that heart attack survivors use caution with exercise, noting moderate levels may be beneficial but higher levels may attenuate the benefits. For heart attack survivors, more exercise is better, up to a point.
- *Accidents.* Given the nature of physical activity, particularly competitive sports, accidental injuries occur, and some may be fatal, such as a concussion causing serious head injury. Use safety gear as appropriate for your physical activity, such as helmets for bicycling, rollerblading, and skiing, as well as other protective sportswear as appropriate for any given activity. Adhere to safety protocols for various activities, such as cycling in traffic. About 700 cyclists are killed annually in the United States in collisions with automobiles. In recent years, reports indicate increasing emergency room visits by those who walk and talk on their cell phones and experience an accident, either by falls or being hit by motor vehicles.

Key Concepts

- Health-related fitness includes a healthy body weight, cardiovascular-respiratory fitness, adequate muscular strength and muscular endurance, and sufficient flexibility.
- Overload is the key principle underlying the adaptations to exercise that may provide a wide array of health benefits. The intensity, duration, and frequency of exercise represent the means to impose an overload on body systems that enable healthful adaptations.
- Physical inactivity may be dangerous to your health. Some contend "Sitting is the new smoking." Exercise, as a form of physical activity, is becoming increasingly important as a means to achieve health benefits, by preventing the development of many chronic diseases.
- Physical activity need not be strenuous to achieve health benefits, but additional benefits may be gained through more vigorous and greater amounts of physical activity.
- In general, more exercise is better, up to a point. Excessive exercise may cause some minor and major health problems in some individuals. You should be aware of personal health issues or other factors that may be related to exercise-associated health risks.

Check for Yourself

- Using an online fitness tracker, track your physical activity for one week. Tally the number of minutes spent engaged in aerobic activities and muscle-strengthening activities. How do these levels compare to the *Physical Activity Guidelines for Americans?* Based on these findings, are there any changes you should make to your fitness?

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Nutrition and Fitness

What is nutrition?

Nutrition is the science of food, the sum total of the processes involved in the intake and utilization of food substances by living organisms, including ingestion, digestion, absorption, transport, and metabolism of nutrients found in food. This definition stresses the biochemical or physiological functions of the food we eat, particularly in relation to health and disease. Additionally, the Academy of Nutrition and Dietetics (AND) notes that nutrition may be interpreted in a broader sense and be affected by a variety of psychological, sociological, and economic factors.

The primary purpose of the food we eat is to provide us with a variety of nutrients. A **nutrient** is a specific substance found in food that performs one or more physiological or biochemical functions in the body. There are six major classes of essential nutrients found in foods: carbohydrates, fats, proteins, vitamins, minerals, and water. However, as noted in chapter 2, food contains substances other than essential nutrients that may affect body functions.

As illustrated in **figure 1.7,** the essential nutrients perform three basic functions. First, they provide energy for human metabolism (see chapter 3). Carbohydrates and fats are the prime sources of energy. Protein may also provide energy, but this is not its major function. Vitamins, minerals, and water are not energy sources. Second, all nutrients are used to promote growth and development by building and repairing body tissue. Protein is the major building material for muscles, other soft tissues, and enzymes, while certain minerals such as calcium and phosphorus make up the skeletal framework. Third, all nutrients are used to help regulate and maintain the diverse physiological processes of human metabolism.

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Promote growth and development

Provide energy

Regulate metabolism

FIGURE 1.7 Foods provide a mix of nutrients. This Buddha bowl with kale salad, quinoa, roasted chickpeas, grilled chicken breast, avocado, baked sweet potatoes, leek sprouted seeds, pine nuts, and sesame seeds is an example of a meal containing multiple essential nutrients.

In order for our bodies to function effectively, we need more than 40 specific nutrients, and we need these nutrients in various amounts as recommended by nutrition scientists. Dietary Reference Intakes (DRI) represent the current recommendations in the United States and include the Recommended Dietary Allowances (RDA), Adequate Intakes (AI), and Tolerable Upper Intake Levels (UL). These recommendations are explained in detail in chapter 2. Nutrient deficiencies or excesses may cause various health problems, some very serious.

What is the role of nutrition in health promotion?

As noted previously, your health is dependent upon the interaction of your genes and your environment, and the food you eat is part of your personal environment.

> ***Let food be your medicine and medicine be your food.***

This statement by Hippocrates, made over two thousand years ago, is becoming increasingly meaningful as the preventative and therapeutic health values of food relative to the development of chronic diseases are being unraveled. Nutrients and other substances in foods may influence gene expression, some having positive and others negative effects on our health. For example, adequate amounts of certain vitamins and minerals may help prevent damage to DNA, the functional component of your genes, while excessive alcohol may lead to DNA damage.

Most chronic diseases have a genetic basis; if one of your parents has had coronary artery disease or cancer, you have an increased probability of contracting that disease. Such diseases may go through three stages: initiation, promotion, and progression. Your genetic predisposition may lead to the initiation stage of the disease, but factors in your environment that influence your epigenome may promote its development and eventual progression. In this regard, some nutrients are believed to be **promoters** that lead to progression of the disease, while other nutrients are believed to be **antipromoters** that deter the initiation process from progressing to a serious health problem.

What you eat plays an important role in the development or progression of a variety of chronic diseases. For example, the CDC indicates that good nutrition lowers people's risk for many chronic diseases, including heart disease, stroke, some types of cancer, diabetes, and osteoporosis (**figure 1.8**). The National Cancer Institute (NCI) estimates that one-third of all cancers are linked in some way to diet, ranking just behind tobacco smoking as one of the major causes of cancer. Research suggests that high adherence to a healthy diet, such as the Mediterranean diet, is associated with a significant reduction in the risk of overall cancer mortality, particularly colorectal, prostate, and aerodigestive cancer.

As noted previously, *exercise is medicine.* In a like manner, *food is medicine* may also be an appropriate phrase, not only attributable to the quote from Hippocrates but also based on modern medicine as well. The types and amount of nutrients and phytochemicals found in our foods, the source of our food, and the method of food

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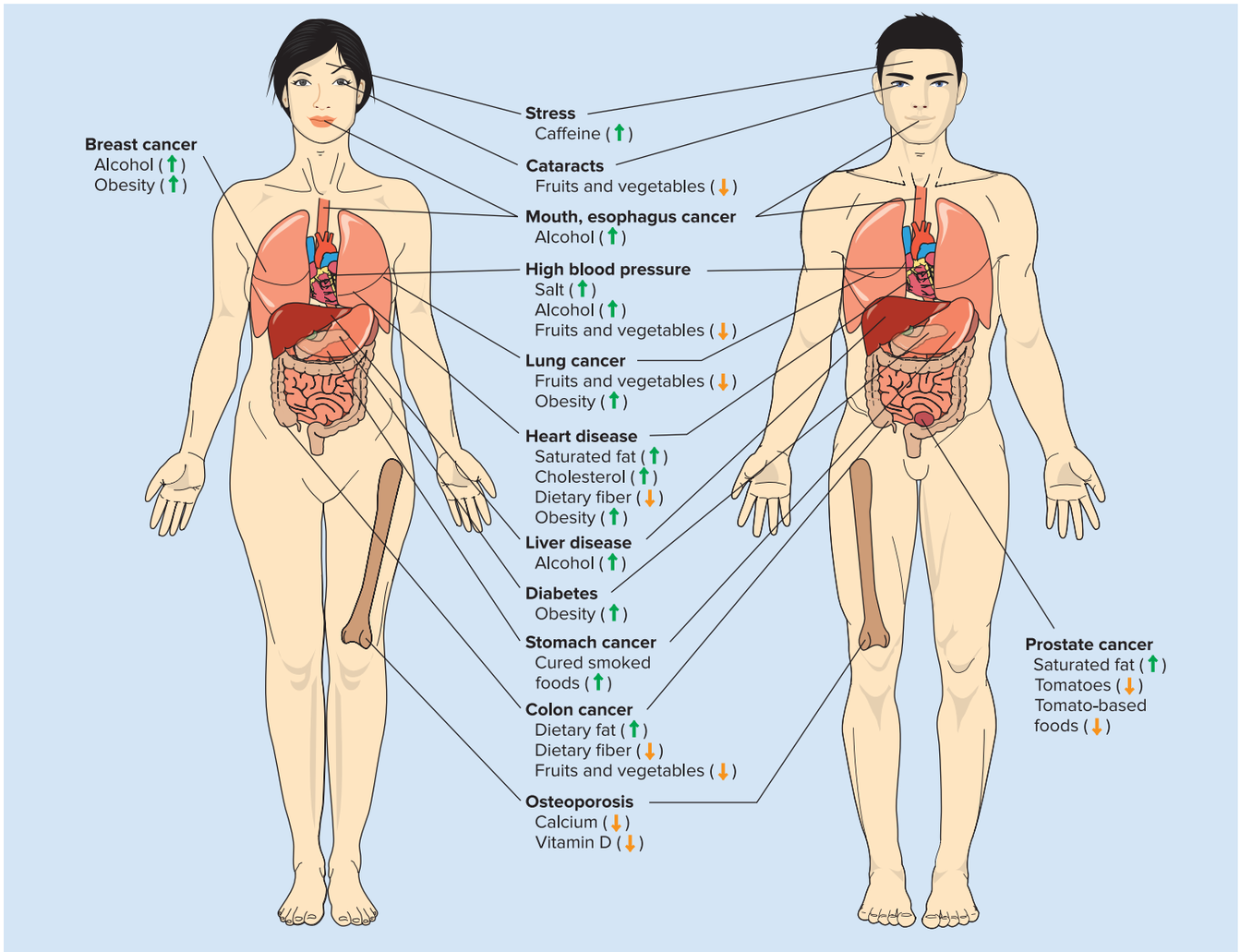

FIGURE 1.8 Some possible health problems associated with poor dietary habits. An upward arrow (↑) indicates excessive intake, while a downward arrow (↓) indicates low intake or deficiency.

preparation are all factors that may influence the epigenome and subsequent gene expression or other metabolic functions that may affect our health status. The *Training Table* in this section summarizes some of the key ways by which nutrients may impact health and risk for chronic disease.

The beneficial, or harmful, effects of specific nutrients and various dietary practices on mechanisms underlying the development of chronic diseases will be discussed as appropriate in later sections of this book.

Do most Americans eat right?

Surveys indicate that most people are aware of the role of nutrition in health and want to eat better for healthful purposes, but they do not translate their desires into appropriate action. Poor eating habits span all age groups. According to the *2015–2020 Dietary Guidelines for Americans* report, on average, Americans of all ages consume too few vegetables, fruits, high-fiber whole grains, low-fat milk products, and seafood and they eat too much added sugars, solid fats, refined grains, and sodium. **Table 1.4** summarizes the five overarching guidelines from the *2015–2020 Dietary Guidelines for Americans*.

According to *Healthy People 2020*, a "healthy" diet is one that limits caloric intake to meet caloric needs (i.e., consuming enough, but not too many, kcal). Such a diet provides a variety of nutrient-dense foods from across the food groups, particularly whole grains, fruits, vegetables, low-fat or fat-free milk or milk products, and lean meats or other sources of protein. As well, a healthy diet is one that limits saturated and *trans* fats, cholesterol, added sugars, sodium, and alcohol.

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TABLE 1.4 Overarching guidelines from the *2015–2020 Dietary Guidelines for Americans*

- Follow a healthy eating pattern across the lifespan.
- Focus on variety, nutrient density, and amount.
- Limit kcal from added sugars and saturated fats and reduce sodium intake.
- Shift to healthier food and beverage choices.
- Support healthy eating patterns for all.

Training Table

The following are some of the proposed effects of various nutrients and appropriate energy intake that may help promote good health:

- Inactivate carcinogens or kill bacteria that damage DNA.
- Help repair DNA.
- Increase insulin sensitivity.
- Relax blood vessels and improve blood flow.
- Reduce blood pressure.
- Optimize serum lipid levels.
- Reduce inflammation.
- Inhibit blood clotting.
- Enhance immune system functions.
- Prevent damaging oxidative processes.
- Dilute harmful chemicals in the intestines.
- Promote more frequent bowel movements.

Some advances are being made in the battle against unhealthy eating, obesity, and poor health in the United States. For example, some food manufacturers have reduced the amounts of solid fats, added sugars, and salt in their products. Some fast-food restaurants are offering healthier alternatives, such as oatmeal with fruit for breakfast, and menu labeling laws now require posting of certain nutrition information. The National School Lunch Program has promoted a program to incorporate more fresh fruit and vegetables into daily school lunches. Although these are worthwhile endeavors, many more are needed before we can state that "We are eating right."

What are some general guidelines for healthy eating?

Because the prevention of chronic diseases is of critical importance, thousands of studies have been and are being conducted to discover the intricacies of how various nutrients may affect our health. Particular interest is focused on nutrient function within cells at the molecular level, the interactions between various nutrients, and the identification of other protective factors in certain foods. All of the answers are not in, but sufficient evidence is available to provide us with some useful, prudent guidelines for healthful eating practices.

Over the past two decades, in response to the need for healthier diets, a variety of public and private health organizations analyzed the research relating diet to health and developed some basic guidelines for the general public. The details underlying these recommendations may be found in several voluminous governmental reports, including the scientific report accompanying the *2015-2020 Dietary Guidelines for Americans* and *Healthy People 2020*. These reports serve as the basis for dietary recommendations provided in the United States Department of Agriculture (USDA) "MyPlate" recommendations. According to MyPlate recommendations, approximately half of a person's "plate" should include fruits and vegetables. Grains and proteins should make up the other half of the plate, and low-fat or fat-free dairy options (or nondairy alternatives) should be included with most meals. **Figure 1.9** provides an image of MyPlate. The www.choosemyplate.gov website provides details about each of the food groups and includes resources appropriate for Americans of all ages.

Although we do have considerable research to support dietary recommendations to promote health, the research is incomplete. Moreover, inconsistencies in research findings, such as the health effects of saturated fat, discussed later in this chapter, may affect recommendations. Thus, the following recommendations may be considered to be prudent, and throughout this book we will refer to these recommendations as a **Prudent Healthy Diet.** These recommendations are in accordance with the *total diet* approach of the AND and the various governmental and professional health organizations noted previously. Each specific dietary recommendation may convey some health benefit, so the more of these dietary guidelines you adopt, the greater should be your overall health benefits. The *Training Table* summarizes the key Prudent Healthy Diet recommendations.

An expanded discussion of these guidelines along with practical recommendations to help you implement them is presented

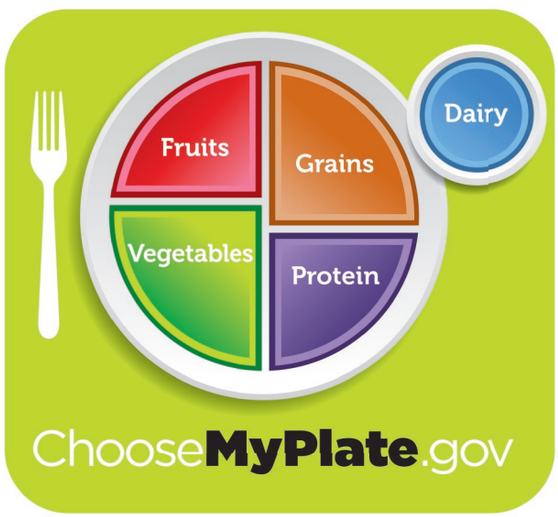

FIGURE 1.9 MyPlate visual showing the relative breakdown of food groups as part of a healthy diet.
Source: US Department of Agriculture

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Training Table

The following are key recommendations of the Prudent Healthy Diet:

1. Balance the food you eat with physical activity to maintain or achieve a healthy body weight. Consume only moderate food portions. Be physically active every day.
2. Eat a nutritionally adequate diet consisting of a wide variety of nutrient-rich foods. Eat more whole foods in their natural form. Eat fewer highly processed foods.
3. Choose a plant-rich diet with plenty of fruits and vegetables, whole-grain products, and legumes, which are rich in complex carbohydrates, phytonutrients, and fiber.
4. Choose a diet moderate in total fat, but low in saturated (solid), *trans* fat and cholesterol.
5. Choose beverages and foods to moderate or reduce your intake of added sugars and highly refined carbohydrates.
6. Choose and prepare foods with less salt and sodium.
7. Maintain protein intake at a moderate yet adequate level, obtaining much of your daily protein from plant sources, complemented with smaller amounts of fish, skinless poultry, and lean meats.
8. Choose a diet adequate in calcium and iron.
9. Practice food safety, including proper food storage, preservation, and preparation.
10. Consider the possible benefits and risks of food additives and dietary supplements.
11. If you drink alcoholic beverages, do so in moderation.
12. Enjoy your food. Eat what you like, but balance it within your overall healthful diet.

in chapter 2. Additional details on how each specific recommendation may affect your health status, including specific considerations for women, children, and the elderly, are presented in appropriate chapters throughout this book. The following websites present detailed information on healthy dietary guidelines:

www.dietaryguidelines.gov The *2015–2020 Dietary Guidelines for Americans* focus on the total diet and how to integrate all of the recommendations into practical terms, encouraging personal choice but result in an eating pattern that is nutrient-dense and kcal-balanced.

www.ChooseMyPlate.gov MyPlate offers personalized eating plans and interactive tools to help you plan your food choices.

www.healthcanada.gc.ca The *Canada Food Guide, Eat Well and Be Active Educational Toolkit* provides excellent information on healthy eating. Click on Food and Nutrition.

www.eatright.org The Academy of Nutrition and Dietetics site provides numerous tips to eating healthy.

Are there additional health benefits when both exercise and diet habits are improved?

A poor diet and physical inactivity are individual major risk factors for the development of chronic diseases. Collectively, however, they may pose additional risks, particularly pre-diabetes, a condition preceding type 2 diabetes, and for the two most deadly chronic diseases—heart disease and cancer. Recent research also indicates certain that dietary factors may complement exercise for enhanced brain function. Thus, combining a recommended exercise program with a healthy diet may have additive effects on one's health.

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Pre-diabetes Several factors, such as excess body weight, impaired fasting blood glucose, and glucose intolerance, may be associated with pre-diabetes and predispose one to type 2 diabetes. Prevention interventions that include diet and both aerobic and resistance exercise training have been found to be modestly effective in reducing risk factors associated with pre-diabetes in adults, which help in the prevention of type 2 diabetes.

Heart Disease Lloyd-Jones and others, discussing the American Heart Association's Strategic Impact Goal through 2020 and beyond, reported that ideal cardiovascular health is associated with physical activity at goal levels and pursuit of a diet consistent with current guideline recommendations. As shown in **table 1.5,** the key

TABLE 1.5 Modifiable risk factors associated with coronary artery disease

Risk factor	Classification	Positive health lifestyle modification
High blood pressure	Major	Proper nutrition, aerobic exercise, maintain or achieve healthy body weight
High blood lipids	Major	Proper nutrition, aerobic exercise
Smoking	Major	Stop smoking
Sedentary lifestyle	Major	Aerobic exercise
ECG abnormalities	Major	Proper nutrition, aerobic exercise
Obesity	Major	Low-kcal diet, aerobic exercise
Diabetes	Major	Proper nutrition, weight loss, aerobic exercise
Stressful lifestyle	Contributory	Stress management
Dietary intake	Contributory	Proper nutrition

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lifestyle behaviors that may be effective in favorably modifying heart disease risk factors are proper nutrition and exercise. Moreover, several of the risk factors for heart disease are diseases themselves, such as diabetes, obesity, and high blood pressure, all of which may benefit from the combination of proper nutrition and exercise.

Cancer In its recent extensive worldwide report on the means to prevent cancer, the American Institute of Cancer Research highlighted the three most important means to prevent a wide variety of cancers, and all are related to exercise and nutrition:

- Choose mostly plant foods, limit red meat, and avoid processed meat.
- Be physically active every day in any way for 30 minutes or more.
- Aim to be a healthy weight throughout life as much as possible.

Brain Health Exercise and nutrition are both powerful means to positively influence the brain and may influence brain health through several mechanisms that create new neurons (neurogenesis). Specifically, exercise collaborates with other aspects of lifestyle to influence cognition. In particular, select dietary factors share brain-enhancement mechanisms similar to exercise, and in some cases can complement the action of exercise. Experts suggest that exercise and diet appear to be effective strategies to counteract neurological and cognitive disorders.

Prevention of chronic diseases is a high priority for most governmental and professional health organizations, and they have developed appropriate healthy lifestyle behaviors to maximize prevention efforts. Most such healthy lifestyle behaviors include exercise and healthful eating. The possible complementary effect of exercise and nutrition on chronic diseases will be presented in later chapters as appropriate.

Key Concepts

- The primary purpose of the food we eat is to provide us with nutrients essential for the numerous physiological and biochemical functions that support life.
- Dietary guidelines developed by major professional health organizations are comparable, and collectively help prevent major chronic diseases such as heart disease, cancer, diabetes, high blood pressure, and obesity.
- Poor eating habits span all ages. The *2015–2020 Dietary Guidelines for Americans* and the *Healthy People 2020* report note that poor nutrition is a major health problem in the United States.
- Basic guidelines for a Prudent Healthy Diet include maintenance of a proper body weight and consumption of a wide variety of natural foods rich in nutrients associated with health benefits. The more healthful dietary guidelines that you adopt, the greater will be your overall health benefits.
- Although both proper exercise and sound nutrition habits may confer health benefits separately, health benefits may be maximized when both healthy exercise and nutrition lifestyles are adopted.

Check for Yourself

- Using a diet analysis program, such as NutritionCalc Plus, create a profile with your personal information and look at your specific dietary recommendations. Then, track your diet for 24 hours, comparing your intake with recommended intakes. Are there key nutrients you are lacking? Are there key nutrients you are consuming in excess?

Sports-Related Fitness: Exercise and Nutrition

As with health, genetic endowment plays an important underlying role in the development of success in sport. In his book *The Sports Gene,* David Epstein notes that nature and nurture are both essential ingredients for superior performance in a given sport. Nature is in the genes, the hardware, whereas nurture is in the environment, the software. Nurture involves not only exposure to the sport at a specific time but expert training as well. Ahmetov and Rogozkin suggest that optimal responses to training are also dependent on possession of appropriate genes. Genes explain why some individuals benefit while others do not from the same sport training program. Elite athletes are not only born with the right genes for a given sport but must also have the right genes to benefit from proper training. Moreover, Joyner and Coyle note that complex motivational and sociological factors also play important roles in who does or does not become a sport champion. For example, one is more likely to be successful in ice hockey if born in Canada rather than Brazil, but the Brazilian child may be more successful in soccer.

What is sports-related fitness?

One of the key factors determining success in sport is the ability to maximize your genetic potential with appropriate physical and mental training to prepare both mind and body for intense competition. As described earlier in this chapter, athletes develop sports-related fitness by training specifically for their sport. For example, strength and power are key to success in sports such as football, bobsled, and shot put. In comparison, endurance training is essential for success in long-distance cycling, running, or swimming. Proper training to develop neuromuscular skills is important for gymnastics, archery, and cross-country skiers participating in the biathlon event. For many sports, such as soccer and basketball, athletes must train appropriately to develop multiple fitness components.

The principles of exercise training introduced earlier, such as overload and specificity, are as applicable to sports-related fitness as they are to health-related fitness. However, training for sports performance is more intense, prolonged, and frequent than training for health, and training is specific to the energy demands and skills associated with each sport. We will discuss energy expenditure for sports performance in chapter 3. The *Training Table* in

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Training Table

The following are examples of general categories of sports, with an example included for each:

- Explosive "power" sports
  - Olympic weight lifting
- Very high-intensity sports
  - 100-meter run
- High-intensity, short-duration sports
  - 5,000-meter run (3.1 miles)
- Intermittent high-intensity sports
  - Soccer
- Endurance sports
  - Marathon running (26.2 miles, 42.2 kilometers)
- Low-endurance, precision skill sports
  - Golf
- Weight-control and body-image sports
  - Bodybuilding

this section provides examples of different sports-related fitness components and examples of each.

Training of elite athletes at the United States Olympic Training Center (USOTC) focuses on three attributes:

- Physical power
- Mental strength
- Mechanical edge

Coaches and scientists work with athletes to maximize physical power production for their specific sport, to optimize mental strength in accordance with the psychological demands of the sport, and to provide the best mechanical edge by improving specific fitness and sport skills, sportswear, and sports equipment. Sports science and technology provide elite competitors with the tiny margins needed to win in world-class competition.

Athletes at all levels of competition, whether an elite international competitor, a college wrestler, a high school volleyball player, a seniors age-group distance runner, or a youth league soccer player, can best improve their sports-related fitness and performance by intense training appropriate for their age, physical and mental development, and sport. For example, in a review as to how we should spend our time and money to improve cycling performance, Jeukendrup and Martin indicated that, of the many ways possible, training is the first and most effective means. To paraphrase Theodore Roosevelt, "Do the best with what you got." While proper training and hard work are essential, sports and exercise scientists have investigated a number of means to improve athletic performance beyond that attributable to training, and one of the most extensively investigated areas has been the effect of nutrition.

What is sports nutrition?

At high levels of athletic competition, athletes generally receive excellent coaching to enhance their biomechanical skills (mechanical edge), sharpen their psychological focus (mental strength), and maximize the physiological functions (physical power) essential for optimal performance. Clyde Williams, a renowned sports scientist from England, notes that, in addition to specialized training, from earliest times certain foods were regarded as essential preparation for sports competition, including the Olympics in ancient Greece.

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As we shall see, there are various dietary factors that may influence biomechanical, psychological, and physiological considerations in sport. For example, losing excess body fat will enhance biomechanical efficiency; consuming carbohydrates during exercise may maintain normal blood sugar levels for the brain and prevent psychological fatigue; and providing adequate dietary iron may ensure optimal oxygen delivery to the muscles. All these sports nutrition factors may favorably affect athletic performance.

Sports nutrition involves the application of nutritional principles to enhance athletic performance. Louise Burke, an internationally renowned sports nutritionist from Australia, defined sports nutrition as the application of eating strategies with several major objectives:

- To promote good health
- To promote adaptations to training
- To recover quickly after each training session
- To perform optimally during competition

Sports nutritionists may meet these objectives in various ways, such as developing meal plans for training, recovery, and competition; coordinating training tables; providing appropriate information about healthy diets; teaching cooking skills; discussing the efficacy, safety, and permissibility of sports supplements; counseling individual athletes with special diets, such as vegetarians; and monitoring athletes for weight loss and eating disorders.

Although investigators have studied the interactions between nutrition and various forms of sport or exercise for more than a hundred years, it is only within the past several decades that extensive research has been undertaken regarding specific recommendations for athletes.

Is sports nutrition a profession?

Sports nutrition is recognized as an important factor for optimal athletic performance. Sports nutrition is sometimes referred to as *exercise nutrition* when coupled with exercise designed for health-related fitness, as discussed in the previous section, but that term is less frequently used. Several factors indicate that sports nutrition has become a profession and is a viable career opportunity.

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Professional Associations Several professional associations, such as the Sports, Cardiovascular, and Wellness Nutrition (SCAN) practice group of the AND, Professionals in Nutrition for Exercise and Sport (PINES), the Collegiate & Professional Sports Dietitians Association (CPSDA), and the International Society of Sports Nutrition (ISSN), are involved in the application of nutrition to sport, health, and wellness.

Certification Programs Several professional and sports-governing organizations have developed a recognized course of study or certification program to promote the development of professionals who can provide athletes with sound information about nutrition. For example, AND has established a program for certification as a Specialist in Sports Dietetics (CSSD), while the International Olympic Committee offers a diploma in sports nutrition.

Research Productivity Numerous exercise-science/nutrition research laboratories at major universities are dedicated to sports nutrition research. Almost every scientific journal in sport/exercise science, and even in general nutrition, appears to contain at least one study or review in each issue that is related to sports nutrition. Several journals, such as the *International Journal of Sport Nutrition and Exercise Metabolism,* focus almost exclusively on sports nutrition.

International Meetings International meetings have focused on sports nutrition, some meetings highlighting nutritional principles for a specific sport, such as soccer or track and field, while others may focus on a specific sport supplement, such as creatine.

Consensus Statements and Position Stands Several international sports-governing organizations have developed consensus statements on nutrition for their specific sport. For example, the International Swimming Federation (Fédération Internationale de Natation, FINA) published a consensus statement on nutrition for the aquatic sports, which is designed to provide sound nutrition information for aquatic athletes worldwide. A more generalized position stand entitled "Nutrition and Athletic Performance" was issued jointly by the AND, the ACSM, and the Dietitians of Canada.

National Sports Nutrition Programs Many countries have developed sports nutrition programs for international competition, such as the Olympic Games. Burke and others reported on such programs for the London Olympic Games.

Career Opportunities Sports nutritionists are employed by professional sport teams and athletic departments of colleges and universities to design optimal nutritional programs for their athletes. Some dietitians market themselves as full-time or part-time sports nutritionists within their communities. Many are members of CPSDA.

www.acsm.org You may access the position stand entitled "Nutrition and Athletic Performance" by clicking on Public Information and then Position Stands.

www.scandpg.org/sports-nutrition/be-a-board-certified-sports-dietitian-cssd/ The SCAN site provides information on what is necessary to become a Board Certified Specialist in Sports Dietetics.

www.sportsoracle.com Check this PINES site to see what is needed to become a member and the requirements for the IOC Diploma in Sports Nutrition.

www.sportsrd.org The CPSDA site provides information on membership.

Are athletes today receiving adequate nutrition?

Numerous survey studies regarding dietary intake of athletes have been conducted over the course of the past two decades and, in general, present mixed results. Based on recommended dietary practices for athletes, the following is a brief summary of the findings.

- Many athletes do not consume adequate amounts of energy, particularly carbohydrate.
- Many athletes consume more dietary fat than recommended, particularly saturated fat.
- Intake of micronutrients, such as vitamins and minerals, varies. Some athletes exceed current recommended intakes, while others have inadequate intakes.
- Athletes involved in weight-control sports who may restrict energy intake may be at high risk for micronutrient deficiencies. Iron and calcium deficiencies may be common in female athletes.
- Many athletes, including youth athletes, take dietary supplements designed to enhance performance.

This brief review indicates that some athletic groups are not receiving the recommended allowances for a variety of essential nutrients or may not be meeting certain recommended standards. It should be noted, however, that these surveys have analyzed the diets of the athletes only in reference to a standard, such as the RDA, and many studies have not analyzed the actual nutrient or biochemical status (such as by a blood test) of the athlete or the effects that the dietary deficiency exerted on exercise performance capacity or sport performance. The RDA for vitamins and minerals incorporates a safety factor, so an individual with a dietary intake of essential nutrients below the RDA may not necessarily suffer a true nutrient deficiency. However, athletes who do develop a nutrient deficiency may experience a deterioration in athletic performance and poor health as a result. Examples discussed in later chapters include impaired aerobic endurance capacity associated with iron deficiency and premature decreases in bone density with calcium deficiency.

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Why are some athletes malnourished?

Studies over the course of the past two decades have indicated a variety of factors that may contribute to poor dietary habits in many athletes, including the following:

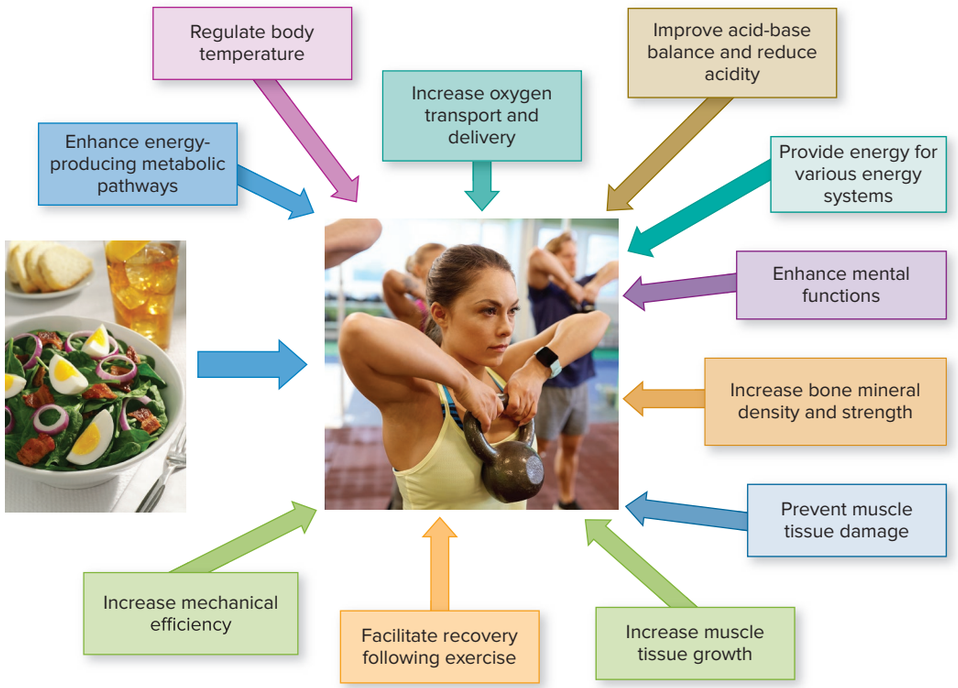
- Athletes may not possess sufficient knowledge to make appropriate food choices.
- Athletes have misconceptions about the roles of specific nutrients in sport performance; if they choose foods based on these misconceptions, then sports performance may suffer.
- Athletes may not be getting sound sports nutrition information. Jacobson and others reported that, although some college varsity athletes received nutrition information from reliable sources, such as dietitians and athletic trainers, considerable nutrition information was obtained from less reliable sources such as websites and coaches with an inadequate education in sports nutrition.
- Finances and time may limit preparation of healthier meals, particularly with college athletes. Healthy meal preparation may take a back seat to time needed for sport practice and class and study time.

However, the future looks bright. SCAN and the CPSDA have partnered with the NCAA Sports Science Institute to publish nutrition information monthly on its website. Along with increased emphasis on sports nutrition education for collegiate strength and conditioning coaches, such endeavors may help improve nutrition among collegiate athletes. Various education programs also are being developed for professional and youth sports by various groups, such as, respectively, the National Football League (NFL) and the PCFSN. Such programs should help. For example, Valliant and others reported a nutrition education program was useful in improving dietary intake and nutrition knowledge of female athletes.

How does nutrition affect athletic performance?

The nutrients in the foods we eat can affect exercise and sports performance in accordance with the three major functions of nutrients. First, nutrients may provide energy for the different energy-producing systems discussed in chapter 3. Second, nutrients also help regulate metabolic processes important to energy production and temperature regulation during exercise. Third, nutrients support the growth and development of specific body tissues and organs as they adapt to exercise training; **figure 1.10** highlights some of the roles diet and nutrients play during exercise. A well-planned sport-specific diet will help optimize sports performance, while a poor diet plan may lead to fatigue and impaired performance.

Malnutrition represents unbalanced nutrition and may exist as either undernutrition or overnutrition, that is, an individual does not receive an adequate intake (*undernutrition*) or consumes excessive amounts of single or multiple nutrients (*overnutrition*). Either condition can hamper athletic performance. An inadequate intake of certain nutrients may impair athletic performance due to an insufficient energy supply, an inability to regulate exercise



Salad: ©TheCrimsonMonkey/Getty Images; Woman: ©Syda Productions/Shutterstock

FIGURE 1.10 Nutrients in the foods we eat and dietary strategies may influence exercise or sport performance in a variety of ways. This figure summarizes some of the key effects of nutrient intake (diet) on physical activity performance.

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metabolism at an optimal level, or a decreased synthesis of key body tissues or enzymes. In contrast, excessive intake of some nutrients may also impair athletic performance, and even the health of the athlete, by disrupting normal physiological processes or leading to undesirable changes in body composition.

What should athletes eat to help optimize sport performance?

Sports nutrition experts agree that the type, amount, composition, and timing of food intake can dramatically affect exercise performance, recovery from exercise, body weight and composition, and health. The importance of nutrition to your athletic performance may depend on a variety of factors, including your gender, your age, your body weight status, your eating and lifestyle patterns, the environment, the type of training you do, and the type of sport or event in which you participate. As an example of the last point, the carbohydrate needs of a golfer or baseball player may vary little from those of the nonathlete, whereas those of a marathon runner or ultraendurance triathlete may be altered significantly during training and competition.

The opinions offered by researchers in the area of exercise and nutrition relative to optimal nutrition for the athlete run the gamut. At one end, certain investigators note that the daily food requirement of athletes is quite similar to the nutritionally balanced diet for everyone else, and therefore no special recommendations are needed. At the other extreme, some, such as sports supplement companies, state that it is almost impossible to obtain all the nutrients the athlete requires from the normal daily intake of food, and for that reason nutrient supplementation is absolutely necessary. Other reviewers advocate a compromise between these two extremes, recognizing the importance of a nutritionally balanced diet but also stressing the importance of increased consumption of specific nutrients or dietary supplements for athletes in certain situations.

The review of the scientific literature presented in this book supports the later point of view. In general, athletes who consume enough kcal to meet their energy needs and who meet the requirements for essential nutrients should be obtaining adequate nutrition. Dietary guidelines for better health, as discussed previously and expanded upon in chapter 2, are the same for optimal physical performance. The key to sound nutrition for the athletic individual is to eat a wide variety of healthful foods.

Although a healthy diet is the foundation of a dietary plan for athletes, modifications may be important for training and competition in various sports. For example, adequate carbohydrate is important as an energy source for aerobic endurance athletes, adequate protein may help optimize muscle development in strength/power athletes, and adequate iron may help ensure adequate oxygen delivery in female athletes. Some basic guidelines regarding eating for training and for competition are presented in chapter 2, whereas details regarding the use of specific nutrients, such as carbohydrate and protein, are presented in the chapter highlighting that nutrient.

Some athletes believe that there are *super* foods or diets that provide a competitive advantage in sports. Numerous *sports supplements* are marketed to athletes with this premise in mind and have been the subject of considerable research by sports nutrition scientists. The following section discusses the general role of such supplements in the enhancement of sports performance, while more details on specific sports supplements are presented in the chapter highlighting that nutrient.

Key Concepts

- Success in sports is primarily dependent on genetic endowment and proper training, but nutrition can also be an important contributing factor.
- The major objectives of sports nutrition are to promote good health and adaptations to training, to recover quickly after each training session, and to perform optimally during competition.
- Studies reveal that, although athletes desire to eat a diet that may enhance sports performance, their knowledge of nutrition is often inadequate, and some are not meeting the dietary recommendations of sports nutritionists.
- In general, the diet that is optimal for health is optimal for sports performance. However, athletes involved in certain sports may benefit from specific dietary modifications.

Ergogenic Aids and Sports Performance: Beyond Training

Since early times, athletes have attempted to use a wide variety of techniques or substances to enhance sports performance beyond the effects that could be obtained through training. In sport and exercise science terminology, such techniques or substances are referred to as **ergogenic aids.**

What is an ergogenic aid?

As mentioned previously, the two key factors important to athletic success are genetic endowment and state of training. At certain levels of competition, the contestants generally have similar genetic athletic abilities and have been exposed to similar training methods, and thus they are fairly evenly matched. Given the emphasis placed on winning, many athletes training for competition are always searching for the ultimate method or ingredient to provide that extra winning edge. Indeed, some suggest that two of the key factors leading to better athletic records in recent years are improved diet and ergogenic aids.

The word *ergogenic* is derived from the Greek words *ergo* (meaning work) and *gen* (meaning production of) and is usually defined as *to increase potential for work output.* In sports, various ergogenic aids, or ergogenics, have been used for their theoretical ability to improve sports performance by enhancing physical power, mental strength, or mechanical edge. There are several different classifications of ergogenic aids, grouped according to the general nature of their application to sport. Mechanical and psychological aids

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are often referred to as *performance-enhancing techniques,* whereas physiological, pharmacological, and nutritional aids involve taking some substance into the body and are known as *performance-enhancing substances.* The *Training Table* in this section lists the major categories of ergogenic aids with an example of one theoretical ergogenic aid for each.

Training Table

Ergogenic aids are now a multibillion-dollar industry. Athletes, from the weekend runner to the elite professional athlete, are often looking for that "extra" competitive edge. The five main categories of ergogenic aids, with an example of each, are provided below.

Mechanical: Mechanical, or biomechanical, aids are designed to increase energy efficiency, to provide a mechanical edge. Lightweight racing shoes may be used by a runner in place of heavier ones so that less energy is needed to move the legs and the economy of running increases.

Psychological: Psychological aids are designed to enhance psychological processes during sport performance, to increase mental strength. Hypnosis, through posthypnotic suggestion, may help remove psychological barriers that limit physiological performance capacity.

Physiological: Physiological aids are designed to augment natural physiological processes to increase physical power. Blood doping, or the infusion of blood into an athlete, may increase oxygen transport capacity and thus increase aerobic endurance. However, its use is illegal.

Pharmacological: Pharmacological aids are drugs designed to influence physiological or psychological processes to increase physical power, mental strength, or mechanical edge. Anabolic steroids, whose use is prohibited in sports, are still used by some athletes to help increase muscle mass, strength, and power.

Nutritional: Nutritional aids are nutrients designed to influence physiological or psychological processes to increase physical power, mental strength, or mechanical edge. Protein supplements may be used by strength-trained athletes in attempts to increase muscle mass because protein is the major dietary constituent of muscle.

Why are nutritional ergogenics so popular?

Dietary supplements marketed to physically active individuals are commonly known as sports nutrition supplements, or simply **sports supplements.** Companies market their products as "Supplements for the Competitive Athlete," and overall sales exceed $25 billion, making such ergogenic aids the most commonly utilized. Sports nutrition supplements can be placed in the following three categories:

- Sports supplements, including powders, pills, and ready-to-drink products
- Nutrition bars and gels
- Sports and energy drinks and shots

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Sports supplements are popular world-wide and are used by all types of athletes: male and female, young and old, professional and amateur. Reports indicate that 90 percent or more of elite, international-class athletes consume dietary supplements. Other surveys document significant use among high school and collegiate athletes, military personnel in elite groups, and fitness club members.

Sports supplements are popular for several reasons. Athletes have believed that certain foods may possess magical qualities, so it is no wonder that a wide array of nutrients or special preparations have been used since time immemorial in attempts to run faster, jump higher, or throw farther. Shrewd advertising and marketing strategies promote this belief, enticing many athletes and physically active individuals to try sports supplements. Many of these products may be endorsed by professional athletes, giving the product an aura of respectability. Specific supplements also may be recommended by coaches and fellow athletes. Additionally, as drug testing in sports gets increasingly sophisticated, leading to greater detection of pharmacological ergogenics, many athletes may resort to sports supplements, believing them to be natural, safe, and legal. However, as noted later, this may not be the case.

Are nutritional ergogenics effective?

There are a number of theoretical nutritional ergogenic aids in each of the six major classifications of nutrients, and athletes have been known to take supplements of almost every nutrient in attempts to improve performance. Here are a few examples:

Carbohydrate. Special metabolites of carbohydrate have been developed to facilitate absorption, storage, and utilization of carbohydrate during exercise.

Fats. Special fatty acids have been used in attempts to provide an alternative fuel to carbohydrate.

Protein. Special amino acids derived from protein have been developed and advertised to be more potent than anabolic steroids in stimulating muscle growth and strength development.

Vitamins. Special vitamin mixtures and even "nonvitamin vitamins," such as vitamin B15, have been ascribed ergogenic qualities ranging from increases in strength to improved vision for sport.

Minerals. Special mineral supplements, such as chromium, vanadium, and boron, have been advertised to promote muscle anabolism.

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Water. Special oxygenated waters have been developed specifically for aerobic endurance athletes, theoretically designed to increase oxygen delivery.

In addition to essential nutrients derived from foods, there are literally hundreds of nonessential substances or compounds that are classified as dietary supplements and targeted to athletes as potent ergogenics. These include creatine, L-carnitine, coenzyme Q10, inosine, octacosonal, and ginseng. Moreover, many products contain multiple ingredients, each purported to enhance sports performance. For example, several of the "energy" drinks on the market include carbohydrates, amino acids, vitamins, minerals, metabolites, herbs, and caffeine.

Supplementation with essential nutrients above and beyond the RDA is not necessary for the vast majority of well-nourished athletes. In general, consumption of specific nutrients above the RDA has not been shown to exert any ergogenic effect on human physical or athletic performance. As well, many sports supplements sold on the market are labeled with various performance-enhancement claims without any scientific evidence. However, there are some exceptions. As noted in chapters 4 through 10, there may be some justification for nutrient supplementation or dietary modification in certain athletes under specific conditions, particularly in cases where nutrient deficiencies may occur. Some specific dietary supplements and food drugs may also possess ergogenic potential under certain circumstances.

The effectiveness of almost all of the popular nutritional ergogenics, including the essential nutrients, the nonessential nutrients, the food drugs caffeine and alcohol, the steroid precursor androstenedione, and other agents, will be covered in this book.

Are nutritional ergogenics safe?

The majority of over-the-counter dietary supplements, particularly those containing essential nutrients, appear to be safe for the general population when taken in recommended dosages. However, some dietary supplements, including sports supplements, may contain ingredients that pose serious health risks in several ways.

The FDA has noted that some sports supplements contain chemicals that have been linked to numerous serious illnesses and even death, particularly when taken in excess. For example, although perceived as safe, many different herbal and dietary supplements have been reported to cause liver injury, but the exact component that is responsible for injury is difficult to discern. In the United States, products used for bodybuilding and weight loss are the most commonly implicated.

Supplements that are mislabeled and contain unlisted substances pose a serious health threat. Some companies are unscrupulous and may add chemicals, such as stimulants or steroids, to help make the product more effective, but which also may have adverse health effects. Another potential problem is that some, particularly younger, athletes may have the mentality that "if one is good, then ten is better" and thus may overdose, increasing the potential health risk of a potentially harmful ingredient.

Fortunately, in the United States, the government is working to require that all ingredients be listed on dietary supplement labels, and hopefully appropriate warnings of any potential health risks will be provided as new laws take effect. Currently, some companies are voluntarily adding warnings in their advertisements and product labels.

Are nutritional ergogenics legal?

The use of pharmaceutical agents to enhance performance in sport has been prohibited by the governing bodies of most organized sports. The use of drugs in sports is known as **doping,** and the World Anti-Doping Agency (WADA) has an extensive list of drugs and doping techniques that have been prohibited.

At present, all essential nutrients are not classified as drugs and are considered to be legal for use in conjunction with athletic competition. Most other food substances and constituents sold as dietary supplements are also legal. However, some dietary supplements are prohibited, such as androstenedione, because they are classified as anabolic steroids, which are prohibited drugs. Nevertheless, such supplements may still be obtained via Internet sales. Other dietary supplements may contain substances that are prohibited; for example, Chinese ephedra and some forms of ginseng may contain ephedrine, a stimulant prohibited in competition. Various athletic governing associations have addressed the issue of sports supplements. For example, the NFL, partnering with the NSF Certified for Sports program, has developed strict requirements for the manufacturing of dietary supplements approved for use by its players. The National Collegiate Athletic Association (NCAA) places supplements for student athletes into three categories:

- Permissible—may be provided by the university. Supplements include vitamins, minerals, sports drinks, energy bars, and similar products.
- Impermissible—may not be provided by the university but may be purchased by the student athlete. These supplements are mainly high-protein products, such as those rich in whey protein.
- Banned—mainly drugs, such as those banned by WADA, including stimulants and anabolic agents. Some prescription drugs may also be banned unless under guidance of a physician.

Evidence suggests that contamination of sports supplements that may cause an athlete to fail a doping test is widespread. Some studies of sports supplements targeted for muscle building and marketed on the internet have reported that up to 25 percent were contaminated with prohibited substances and note that many athletes, including Olympic champions, who have claimed they have not taken drugs, but only dietary supplements, have tested positive for doping.

It is hoped that, with pending legislation, all ingredients will be listed in correct amounts on dietary supplement labels. In the meantime, athletes should consult with appropriate authorities before using any sports nutrition supplements marketed as performance enhancers.

Some organizations, such as NSF International, have created programs such as NSF Certified for Sport®, designed to minimize the risk of contaminated sports supplements. Another such group is Informed-Sport. You can learn more about each of these programs by visiting www.nsfsport.com and www.informed-sport.com.

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Despite such programs being available, WADA notes that the use of nutritional or dietary supplements is completely at the athlete's own risk, even if the supplements are labeled as "approved" or "verified."

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Where can I find more detailed information on sports supplements?

Although details on various sports supplements are presented in later chapters, space limitations prevent detailed accounts of each and every supplement available on the market. The following resources may provide detailed information regarding efficacy and safety of numerous supplements, including sports supplements.

This USDA website provides numerous links to ergogenic aids and dietary supplements marketed to athletes, and you can search for specific supplements. You may access this information at www.nutrition.gov/dietary-supplements/dietary-supplements-athletes.

The Australian Institute of Sport (AIS) provides a comprehensive coverage of sports supplements in four categories based on scientific evidence:

A–supported for use in specific sports situations
B–deserving of additional research
C–have little meaningful proof of beneficial effects
D–banned or high risk of containing substances that could lead to a positive doping test

The site also contains a section, A–Z Factsheets, that contains more detailed coverage of some supplements. You may access this information at www.ausport.gov.au/ais/nutrition/supplements.

Key Concepts

- Probably the most prevalent ergogenic aids used to increase sports performance are those classified as nutritional, for theoretical nutritional aids may be found in all six classes of nutrients.
- Although many sports supplements are safe and legal, most are not effective ergogenic aids, and some are unsafe or illegal. Before using a sports supplement, athletes should try to determine if it is effective, if it is safe, and if it is legal.

Check for Yourself

- Go to a health food store, peruse the multiple dietary supplements available, and ask the clerk for advice on a supplement to help you enhance your sports performance, such as increasing your muscle mass or losing body fat. Write down the advice and check out advertisements on the internet. Then, research the supplements on the websites noted in this chapter and compare the findings.

Nutritional Quackery in Health and Sports

Increasing numbers of dietary supplements are being marketed to the general population as health enhancers and to athletes as performance enhancers. Unfortunately, many of the products that advertise extravagant claims of enhanced health or performance are promoted by unscrupulous entrepreneurs, have no legitimate basis, and may be regarded as quackery.

What is nutritional quackery?

According to the Food and Drug Administration (FDA), **quackery,** as the term is used today, refers not only to the fake practitioner but also to the worthless product and the deceitful promotion of that product. Untrue or misleading claims that are deliberately or fraudulently made for any product, including food products, constitute quackery. Such misinformation can have harmful effects on the health and economic status of consumers.

Knowledge relative to all facets of life, the science of nutrition included, has increased significantly in recent years. Thousands of studies have been conducted, revealing facts to help unravel some of the mysteries of human nutrition. The AND indicates that consumers are taking greater responsibility for self-care and are eager to receive food and nutrition information. However, that creates opportunities for nutrition *mis*information, health fraud, and quackery to flourish. As well, according to the AND, while the media are consumers' leading source of nutrition information, news reports of nutrition research often provide inadequate depth for consumers to make wise decisions. Certain individuals may capitalize on these research findings for personal financial gain. For example, isolated nutritional facts may be distorted or the results of a single study will be used to market a specific nutritional product. Health hustlers will use this information to capitalize on people's fears and hopes, be it the fear that the nutritional quality of our food is being lessened by modern processing methods or the hope of improved athletic performance capacity.

Health quackery is big business. Reports suggest that Americans spend almost $27 billion annually on questionable health practices. A substantial percentage of this amount is spent on unnecessary nutritional products. Authorities in this area have noted that the amount of misinformation about nutrition is overwhelming, and it is circulated widely, particularly by those who may profit from it. Although we may still think of quacks as "sleazy" individuals selling patent medicine from a covered wagon, the truth is quite different. Nutritional quacks today are super salespeople, using questionable scientific information to give their products a sense of authenticity and credibility and using sophisticated advertising and marketing techniques.

As noted previously, there are some well-researched health benefits associated with the foods we eat. Federal legislation in the United States allows for the placement of FDA-approved health claims on food packaging. For example, a health claim that the consumption of macadamia nuts may reduce risk of heart disease was approved by the FDA in July 2017. Such may not be the case,

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however, with dietary supplements, which are not regulated in the same way as packaged food products. Therefore, claims posted on dietary supplement labels have not been through the rigorous approval process required of food products.

Before the passage of the 1994 Dietary Supplement Health and Education Act (DSHEA), many extravagant health claims were made by some unscrupulous companies in the food supplement industry. As an example, the deceptive label of one secret formula noted that it would help you lose excess body fat while sleeping, a false claim. Although the DSHEA was designed to eradicate such fraudulent health claims, dietary supplements today appear to have more leeway than packaged foods to imply health benefits. Technically, labels on dietary supplements are not permitted to display scientifically unsupported claims. However, companies are allowed to make general health claims like "boosts the immune system" if, for example, the product contains a nutrient, such as zinc, that has been deemed important in some way to immune functions in the body. Although companies may not claim that the product prevents diseases associated with impaired immune functions, such as the common cold, cancer, or AIDS, the consumer may erroneously make such an assumption.

Many companies now use a disclaimer for general health claims on their labels, noting "These statements have not been evaluated by the Food and Drug Administration" and "This product is not intended to diagnose, treat, cure, or prevent any disease." Companies may also circumvent government regulations by using *freedom of the press.* They may provide information in the form of a reprint of an article, a brochure with highlighted research, or other printed materials that are distributed in connection with the sale of the product. Many dietary supplement companies also have developed online marketing tools to provide comparable biased advertising information to potential consumers.

Although these advertising strategies may contain fraudulent information, the federal agencies that monitor such practices are understaffed and cannot litigate every case of misleading or dishonest advertising. Thus, unsuspecting consumers may be lured into buying an expensive health-food supplement that has no scientific support of its effectiveness.

Nutritional quackery is widespread, as documented in the position stand on food and nutrition misinformation by the AND. Years ago J. V. Durnin, an international authority on nutrition and exercise, stated that there is still no sphere of nutrition in which faddism, misconceptions, ignorance, and quackery are more obvious than in athletics, a situation that continues today.

Why is nutritional quackery so prevalent in athletics?

As with nutritional quackery in general, hope and fear are the motivating factors underlying the use of nutritional supplements by athletes. They hope that a special nutrient concoction will provide them with a slight competitive edge, and they fear losing if they do not do everything possible to win.

Various factors within the athletic environment help nurture these hopes and fears, but the most significant factor contributing to nutritional quackery in sports is direct advertising, as caricatured by the fabricated advertisement in **figure 1.11.** If you scan

FIGURE 1.11 Simulated nutritional supplement advertisement aimed at athletes.

through various magazines targeting bodybuilders or endurance athletes, you will see dozens of advertisements suggesting enhancement of strength, endurance, and sports performance. Such advertisements often use endorsements by star athletes. However, in most cases, there is little or no research supporting the purported ergogenic effects of the advertised supplement.

Additionally, many sports magazines will run articles on the ergogenic benefits of a particular nutrient and in close proximity to the article place an advertisement for a product that contains that nutrient. Freedom of speech guaranteed by the First Amendment permits the author of the article to make sensational and deceptive claims about the nutrient. However, freedom of speech does not extend to advertising, so fraudulent or deceptive claims may be grounds for prosecution by the FDA or the Federal Trade Commission (FTC). Thus, by cleverly positioning the article and the advertisement, the promoter can make the desired claims about the value of the product and yet avoid any illegality. Classic examples of this technique may be found with protein and amino acid supplement advertising in magazines for bodybuilders. Moreover, many advertisements now appear in a format designed to look like a scientific review, though in actuality they are deceptive advertisements for sports supplements. Check the top of the page of such articles and you will find *Advertisement* in small print.

Most of these advertised products are economic frauds. The prices are exorbitant in comparison to the same amount of nutrients that may be obtained in ordinary foods. Besides being an economic fraud, these products are an intellectual fraud, for there is very little scientific evidence to support their claims. Simple basic facts about the physiological functions of the nutrients in these products are distorted, magnified, and advertised in such a way as

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to make one believe that they will increase athletic performance. Unfortunately, in the area of nutrition and sport, it is very easy to distort the truth and appeal to the psychological emotions of the athlete. In many cases, supplements are manufactured by a third party and sold to many different companies, which market them under their personal brand and slick advertising.

How do I recognize nutritional quackery in health and sports?

It is often difficult to differentiate between quackery and reputable nutritional information. The *Training Table* in this section provides practical advice for consumers when evaluating advertisements for nutritional supplements.

Training Table

How can you tell if the claims made on advertisements for a nutritional supplement are true or nutritional quackery? Read through this list and, if the answer is "yes," to any of the questions, you should be skeptical of such supplements and investigate their value before investing any money.

- Does the product promise quick improvements in health or physical performance?
- Does it contain a secret or magical ingredient or formula?
- Is it advertised mainly by use of anecdotes, case histories, or testimonials?
- Are currently popular personalities or star athletes featured in its advertisements?
- Does it take a simple truth about a nutrient and exaggerate that truth in terms of health or physical performance?
- Does it question the integrity of the scientific or medical establishment?
- Is it advertised on a health or sports-magazine website whose publishers also sell nutritional aids?
- Does the person who recommends it also sell the product?
- Does it use the results of a single study or dated and poorly controlled research to support its claims?
- Is it expensive, especially when compared to the cost of equivalent nutrients that may be obtained from ordinary foods?
- Is it a recent discovery not available from any other source?
- Is its claim too good to be true? Does it promise the impossible?

For additional information on identifying nutritional quackery, visit www.dietitian.com/quack.

Where can I get sound nutritional information to combat quackery in health and sports?

The best means to evaluate claims of enhanced health or sports performance made by dietary supplements or other nutritional practices is to possess a good background in nutrition and a familiarity with related high-quality research. Unfortunately, many individuals, including most athletes, coaches, and health professionals, have not been exposed to such an educational program, so they must either take formal course work in nutrition or sports nutrition, develop a reading program in nutrition for health and sport, or consult with an expert in the field.

This book has been designed to serve as a text for a college course in nutrition for health-related and sports-related fitness, but it may also be read independently. It is an attempt to analyze and interpret the available scientific literature as to how nutrition may affect health and sports performance and to provide some simple guidelines for physically active individuals to help improve their health or athletic performance. It should provide the essential science-based (evidence-based) information you need to plan an effective nutritional program, either for yourself, other physically active individuals, or athletes, and to evaluate the usefulness of many nutritional supplements or practices designed to improve health or sports performance. Here are some key resources.

Books Numerous reputable books that detail the relationship of nutrition to health and sports performance are available. However, some books, such as diet books based on an author's personal experiences, may not contain reputable information. A good guide is to check the author's credentials.

Government, Health Professional, Consumer, and Commercial Organizations and Related Websites Accurate information relating nutrition to health is published by governmental agencies such as the FDA and USDA; health professional groups such as the AND, ACSM, Dietitians of Canada, and American Medical Association; consumer groups such as Consumers Union and Center for Science in the Public Interest; and some commercial groups such as the National Dairy Council and the PepsiCo's Gatorade Sports Science Institute. As noted previously, the AIS provides detailed, accurate information on a wide variety of sports supplements. Excellent materials relative to nutrition may be obtained free or at small cost from some of these organizations.

www.hsph.harvard.edu/nutritionsource
Website for nutrition information from the Harvard School of Public Health.

www.gssiweb.com Website for the Gatorade Sports Science Institute, providing detailed reviews on various topics in sports nutrition.

www.healthfinder.gov U.S. Department of Health and Human Services website for information on various health topics, including nutrition.

http://medlineplus.gov National Library of Medicine, a comprehensive health-information retrieval website.

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Scientific Journals Many scientific journals publish reputable findings about nutrition, exercise, and health. These technical journals may not be readily available in public libraries but may be found in university and medical libraries. Examples of such publications include *Medicine & Science in Sports & Exercise, Journal of the Academy of Nutrition and Dietetics, American Journal of Clinical Nutrition, Sports Medicine,* and *International Journal of Sport Nutrition and Exercise Metabolism.*

www.pubmed.gov National Library of Medicine website provides abstracts of original research studies and excellent reviews and meta-analyses published in scientific medical journals. Free full-text articles are provided for some journals. Many colleges and universities also subscribe to a wide variety of health-related professional journals. Check with the library at your college or university for access to journal articles.

www.eatright.org Contact the Academy of Nutrition and Dietetics for the names of local dietitians, as well as other sources of sound nutrition information.

www.scandpg.org/search-rd Use this website to find a sports dietitian. Click on your state to find one closest to you. Those with the CSSD designation have earned the designation as a Board Certified Specialist in Sports Dietetics.

Popular Magazines Articles in popular health and sports magazines may or may not be accurate. The credentials of the author, if listed, should be a good guide to an article's authenticity. A Ph.D. listed after the author's name may not guarantee accuracy of the content of the article. Be wary of publications emanating from organizations or publishers that also sell nutritional supplements.

Consultants Nutritional consultants are another source of information. Such consultants should have a solid background in nutrition, particularly sports nutrition, if they are to advise athletes. The consultant should be a registered dietitian nutritionist (RD or RDN) or possess appropriate professional certification, such as the Certified Nutrition Specialist (CNS). He or she should be a member of a reputable organization of nutritionists, such as the AND, which can be contacted at its website address to provide you with the name of a local dietitian. Other recognized nutritional organizations include the American Society for Nutrition, the American College of Nutrition, and the Dietitians of Canada.

As noted previously, the AND Commission on Dietetic Registration, working with members of the SCAN practice group, has developed a certification program for RDN's who work in sports to achieve the status of Board Certified Specialist in Sports Dietetics (CSSD). A qualified sports dietitian will be able to assess your nutritional status, including variables such as body composition, dietary analysis, and eating and lifestyle patterns, and relate these nutritional factors to the physiological and related nutritional demands of your sport or exercise program, providing you with a plan to help you reach your performance goals.

Be wary of individuals who do not possess professional degrees or appropriate certification, such as "experts" in nutrition or fitness. Many states do not have regulations restricting the use of various terms, such as *nutritionist* or *fitness professional.* Although these individuals may have some practical experience with helping people change their diets and initiate exercise programs, they normally do not have the depth of knowledge required in some cases. For proper nutritional advice, be certain to ask for proof of certification from recognized nutrition professional groups as cited previously. For fitness professionals, check for certification by such groups as the ACSM, the American Council on Exercise (ACE), or the National Strength and Conditioning Association (NSCA).

Cautions on Using the Internet The U.S. Department of Health and Human Services has recommended caution in using the internet to find health information. Along with others, here are some of its major points:

- No one regulates information on the internet. Thus, anyone can set up a home page and claim anything.
- Some official-sounding websites, such as Wikipedia, permit anyone to enter or modify the information presented.
- Search engines, such as Google and Yahoo, host paid advertisements which usually have priority listing and may contain biased information.
- Compare the information you find on the internet with other resources, such as medical journals and textbooks.
- Check the author's or organization's credentials. Unfortunately, there are many so-called nutritionists and other health professionals making false claims on the internet.
- Be wary of websites advertising and selling products that claim to improve your health.
- Be cautious when using information found on bulletin boards or during chat sessions with others.
- Don't believe everything you read.

Several websites listed previously provide reputable information. Although some commercial (.com) and organization (.org) websites provide trustworthy information and may be cited in this text, others may not be as reputable, as they may be sponsored by unethical supplement companies. In general, education (.edu) and government (.gov) websites provide trustworthy information. The websites cited in this text are deemed to be reliable.

For those who would like to view a National Library of Medicine tutorial on evaluating internet health information, visit www.medlineplus.gov/webeval/.

Key Concepts

- Nutritional quackery is widespread as related to the purported benefits of specific dietary supplements. This is particularly the case with dietary supplements marketed to physically active individuals.

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- There are a number of guidelines to help identify quackery and false claims regarding dietary supplements, but one of the critical points to consider is if the claim simply appears to be too good to be true.
- The best means to counteract nutritional quackery is to possess a good background in nutrition. Reputable sources of information are available to help provide contemporary viewpoints on the efficacy, safety, and legality of various dietary supplements for health or sport.

Research and Evidence-Based Recommendations

As discussed throughout this chapter, nutrition and exercise may influence health and sports performance. But how do we know what effect a nutrient, food, or dietary supplement we consume or exercise program we undertake will have on *our* health or performance? To find answers to specific questions, we should rely on the findings derived from scientific research, which is the heart of *evidence-based* medicine. As sophisticated sciences, nutrition and exercise science have a relatively short history. Not too long ago, nutrition scientists were concerned primarily with identifying the major constituents of the foods we eat and their general functions in the human body, while those investigating exercise concentrated more on its application to enhance sports performance. Over time, however, numerous scientists have turned their attention to the possible health benefits of certain foods and various forms of exercise, and, in the case of sports scientists, the possible applications to athletic performance. These scientists are not only attempting to determine the general effects of diet and exercise on health and performance, but also investigating the effects of specific nutrients at the molecular and genetic levels to determine possible mechanisms of action to improve health or performance in sport.

Because this book makes a number of nutritional (and some exercise) *evidence-based* recommendations relative to sports and health, it is important to review briefly the nature and limitations of nutritional and exercise research with humans. For the purpose of this discussion, our emphasis will be on nutritional research, although the same research considerations apply to exercise as well.

What types of research provide valid information?

Several research techniques have been used to explore the effects of nutrition on health or athletic performance. The two major general categories have been epidemiological research and experimental research.

Epidemiological research, also known as *observational research,* involves studying large populations to find relationships between two or more variables, such as dietary fat and heart disease. However, the treatment of interest, such as dietary fat, is not assigned to the subjects. Their normal diet and its relationship to the development of heart disease is the main variable of interest. There are various forms of epidemiological research. One general form uses retrospective techniques. In this case, individuals who have a certain disease are identified and compared with a group of their peers, called a *cohort,* who do not have the disease. Researchers then trace the history of both groups through interviewing techniques to identify dietary practices that may have increased the risk for developing the disease. Another general form of epidemiological research uses prospective techniques. In this case, individuals who are free of a specific disease are identified and then followed for years, during which time their diets are scrutinized. As some individuals develop the disease and others do not, the investigators then attempt to determine what dietary behaviors may increase the risk for the disease.

Epidemiological research helps scientists identify important relationships between nutritional practices and health. For example, years ago several epidemiological studies reported that individuals who consumed a diet high in fat were more likely to develop heart disease. One should note that such epidemiological research does not prove a cause-and-effect relationship. Although these studies did note a deleterious association between a diet high in fat and heart disease, they did not actually prove that fat consumption (possible cause) leads to heart disease (possible effect), but only that some form of relationship between the two existed. However, in some cases, the relationship between a lifestyle behavior and a disease is so strong that causality is inferred. In this regard, epidemiologists often calculate and report relative risks (RR) or odds ratios (OR), which are probability estimates of getting some disease by practicing some unhealthful behavior. An RR of 1.0 is normal probability, so if a study reports an RR of 2.5 for developing heart disease in individuals who consumed a diet rich in saturated fatty acids, such diets may increase one's risk 2.5 times normal. Conversely, if a study reports an RR of 0.5 for developing heart disease by consuming a purely vegetarian diet, such diets may cut heart disease risk in half. Epidemiological research is useful in identifying relationships between variables and generating hypotheses and is often a precursor to experimental research, but it does not prove a cause-and-effect relationship.

Experimental research is essential to establishing a cause-and-effect relationship (**figure 1.12**). In human nutrition research, experimental studies are often referred to as *randomized clinical trials (RCTs)* or *intervention studies,* usually involving a treatment group and a control, or placebo, group. RCTs may involve studying a smaller group of subjects under tightly controlled conditions for a short time frame or larger population groups living freely over a long time frame. In RCTs, an independent variable (cause) is manipulated so that changes in a dependent variable (effect) can be studied. If we continue with the example of fat and heart disease, a large (and expensive) clinical intervention study could be designed to see whether a low-saturated fat diet could help prevent heart disease. Two groups of subjects would be matched on several risk factors associated with the development of heart disease, and over a certain time, say ten years, one group would receive a low-saturated fat diet (treatment, or

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FIGURE 1.12 Well-controlled experimental research serves as the basis underlying recommendations for the use of nutritional strategies to enhance health status or sports performance.

cause) while the other would continue to consume their normal high-saturated fat diet (control or placebo). At the end of the experiment, the differences in the incidence of heart disease (effect) between the two groups would be evaluated to determine whether or not the low-fat diet was an effective preventive strategy. Bouchard presents an excellent, detailed overview of the quality of different research-based sources of evidence, noting that RCTs with large populations represent one of the richest sources of data. If the results of an RCT showed that consumption of a low-saturated fat diet had no effect upon the incidence rate of heart disease, should you continue to consume a high-saturated fat diet? The answer to this question, as we shall see later, is "not necessarily."

Most of the research designed to explore the effect of nutrition on sports performance is experimental in nature, and of a much shorter duration than studies investigating the relationship of nutrition and health. Additionally, most sports nutrition studies are conducted in a laboratory with tight control of extraneous variables. Very few studies have actually investigated the effect of nutritional strategies on actual competitive sports performance. Nevertheless, although most of our information about the beneficial effects of various nutritional strategies on sports performance is derived from laboratory-based research, many of these studies use laboratory protocols designed to mimic the physiological demands of a specific sport. In later chapters, as we discuss the effects of various nutritional strategies or dietary supplements on sports performance, we will often refer to studies that have problems with their experimental methodology, but we will also note studies that were well controlled. The *Training Table* in this section provides examples of some major questions you should ask when evaluating the experimental methodology of a study. We use creatine supplementation as an example.

Training Table

How can you tell if a research study was well-designed? For this example, we will use research investigating creatine supplementation as a means to increase muscular strength and power in athletes. The following are some major questions you should ask about the experimental methodology:

- **Is there a legitimate reason for creatine supplementation in athletes?** Yes! Theoretically, creatine may add to the stores of creatine phosphate in the muscle and serve as a source of energy.
- **Were appropriate subjects used?** Yes! As creatine phosphate may theoretically benefit power performance, trained strength exercises would be ideal subjects.
- **Are the performance tests valid?** Validated tests should be used to collect data on the dependent variable, in this case valid strength and power tests.
- **Was a placebo control used?** A placebo similar in appearance and taste to the creatine supplement should be used as the control.
- **Were the subjects randomly assigned to treatments?** Subjects should be randomly assigned to separate groups, either the treatment (creatine) or control (placebo) group.
- **Was the study double-blind?** Neither the investigators nor the subjects should know which groups received the treatment or the placebo until the conclusion of the study.
- **Were extraneous factors controlled?** Investigators should try to control other factors that may influence power, such as physical training, diet, and activity prior to testing.
- **Was the data properly analyzed?** Appropriate statistical techniques should be used to reduce the risk of statistical error. Using a reasonable number of subjects also helps to minimize statistical error.

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Why do we often hear contradictory advice about the effects of nutrition on health or physical performance?

It is very difficult to conduct nutritional research about health and athletic performance with human subjects. For example, many diseases, such as cancer and heart disease, are caused by the interaction of multiple risk factors and may take many years to develop. It is not an easy task to control all of these risk factors in freely living human beings so that one independent variable, like dietary fat, can be isolated to study its effect on the development of heart disease over 10 or 20 years. In a similar manner, numerous physiological, psychological, and biomechanical factors also influence athletic performance on any given day. Why can't athletes match their personal records day after day, such as the world-record 43.03-second 400-meter dash performance by Wayde van Niekerk? Because their physiology and psychology vary from day to day and even within the day.

Although well-designed studies in peer-reviewed scientific journals serve as the basis for making an informed decision as to whether or not to use a particular nutritional strategy or dietary supplement to enhance health or sports performance, it is important to realize that the results from a single study with humans do not prove anything. For example, Ioannidis noted that even the most highly cited RCTs, particularly small ones with a limited number of subjects, may be challenged and refuted over time. While most investigators attempt to control extraneous factors that may interfere with the interpretation of the results of their study, there may be some unknown factor that leads to an erroneous conclusion. For example, investigators studying the effect of creatine supplementation need to control dietary intake prior to testing. If not, consumption by some subjects of beverages containing caffeine, an effective ergogenic aid, could confound the results. Consequently, for this and other reasons, the results of single studies, whether epidemiological or experimental, should be considered with caution.

The Center for Science in the Public Interest published an article entitled "Behind the Headlines," noting that headlines often neglect to consider important limitations to the study. In this regard, Wellman and others indicated that, unfortunately, all too often the media make bold headlines based on the findings of an individual study, and often these headlines inadvertently exaggerate the findings of the study and their importance to health or physical performance. For example, a newspaper headline might blare "Coffee drinking causes heart disease" after a study is published indicating that coffee drinking could increase blood cholesterol levels slightly. The study did *not* show that coffee drinking caused heart disease, but only that it may have adversely affected one of its risk factors. A year or so later one may read headlines that report "Coffee drinking does not cause heart disease" because a more recent individual study did not find an association between coffee use and serum cholesterol levels. Is it no wonder consumers are often confused about nutrition and its effects on health or sports performance? Overall, most experts agree that nutrition scientists should be more involved in helping the media accurately convey diet and health messages.

https://cspinet.org/resource/behind-headlines The Center for Science in the Public Interest provides resources to help consumers make informed decisions when reading health-related news stories.

For the purpose of improving public understanding, the National Cancer Institute provided some guidelines that journalists and others in the communications business can use for reporting health-related nutrition research. The *Training Table* in this section outlines some of the key recommendations.

Training Table

Journalists and health professionals are often responsible for relaying health-related nutrition to the general public and patients. To improve public understanding of the research, the following key points should be considered:

- **The quality and credibility of the study.** Was it well-designed and published in a high-quality journal?
- **Peer-reviewed study or presentation at a meeting.** Was it presented at a meeting, which normally does not require a review by other scientists?
- **Comparison of findings to other studies.** Was the study compared to other studies reporting contrasting findings?
- **Putting findings into context, such as a risk–benefit assessment.** Are the health risks meaningful? An increased health risk from one in a million to three in a million, if reported as a threefold increase, may appear to be more meaningful than it really is.
- **Funding sources.** Was it funded by a company that could benefit financially from the results?

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What is the basis for the dietary recommendations presented in this book?

Scientists consider each single study as only one piece of the puzzle in attempting to find the truth. To evaluate the effects of nutritional strategies or dietary supplements on health or sports performance, individual studies should be repeated by other scientists and, if possible, a consensus developed. Reviews and

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meta-analyses provide a stronger foundation than the results of an individual study.

In reviews, an investigator analyzes most or all of the research on a particular topic and usually offers a summarization and conclusion. However, the conclusion may be influenced by the studies reviewed or by the reviewer's orientation. There have been instances in which different reviewers evaluated the same studies and came up with diametrically opposed conclusions.

Meta-analysis, a review process that involves a statistical analysis of previously published studies, may actually provide a quantification and the strongest evidence available relative to the effect of nutritional strategies or dietary supplements on health or sports performance. According to Binns and others, the meta-analysis is the gold standard for evidence-based clinical practice guidelines.

The value of reviews and meta-analyses is based on the quantity and quality of studies reviewed. If the number of studies is limited and they are not well controlled, or if improper procedures are used in analyzing and comparing the findings of each study, the conclusions may be inaccurate. For example, Hart and Dey noted that three meta-analyses of the use of Echinacea for the prevention of colds had somewhat different conclusions, as selection criteria for studies used in the analysis varied. Nevertheless, well-designed reviews and, in particular, meta-analyses provide us with valuable data to make prudent decisions. Position statements and position stands of various groups, such as the ACSM and AND, are developed using an *evidence-based* approach, which includes an evaluation of the quality of the studies reviewed. Such groups normally use only RCTs to support their position on specific topics. A number of such position statements are cited throughout this text where relevant.

Comparable to the science of other human behaviors, the science of human exercise and nutrition is not, as many may believe, exact. Although in many cases we still do not have absolute proof that a particular nutritional practice will produce the desired effect, we do have sufficient information to make a recommendation that is prudent, meaning that it is likely to do some good and cause no harm. Thus, the recommendations offered in this text should be considered evidence-based; they are based upon a careful analysis and evaluation of the available scientific literature, primarily comprehensive reviews and meta-analyses of the pertinent research by various scientists or public and private health or sports organizations.

www.nel.gov The USDA Nutrition Evidence Library collaborates with leading scientists using state-of-the-art methodology to review, evaluate, and synthesize research to answer important diet-related questions.

How does all this relate to me?

Remember that we all possess biological individuality and thus might react differently to a particular nutritional or exercise intervention. For example, relative to health, many of us have little or no reaction to an increase in dietary salt, but some individuals are very sensitive to salt intake and will experience a significant rise in blood pressure with increased dietary salt. Relative to athletic performance, Mann and others note there are high responders and low responders to the same standardized exercise training program, some individuals improving markedly but others less so. Such individual reactions have been noted in some research studies and are discussed where relevant in the following chapters. With advances in genetic technology, diets and exercise training may one day be individualized to conform to our genetically determined favorable responses to particular dietary strategies. However, to our knowledge, individualized diets and exercise training for health or sports performance based on one's genetic profile have not yet been developed. For example, Sales and others note that the science of nutrigenomics seeks to explain the interactions between genes and nutrients in order to customize diets according to each individual's genotype, which may help prevent some chronic diseases. Moreover, in a major review of the genomics of elite sporting performance, Wang and others noted that progress has been made, such as identifying single genes with sprint or endurance performance, but they note that only after a lengthy and costly process will the true potential of genetic testing in sport be determined.


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Thus, recommendations offered in this text should not be regarded as medical advice. Individuals should consult a physician or another appropriate health professional for advice on taking any dietary supplement for health purposes. Additionally, although information presented in this book may help athletes make informed decisions regarding the use of nutritional strategies as a means to improve sports performance, athletes should confer with an appropriate health professional before using sports supplements or nutritional ergogenics.

Key Concepts

- Epidemiological research helps to identify relationships between nutritional practice and health or sports performance and may be helpful in developing hypotheses for experimental research. However, experimental studies, such as randomized controlled trials, are needed to establish a cause-effect relationship. Such experimental studies should adhere to appropriate research design protocols.
- Nutritional recommendations for enhancement of health or athletic performance are based on reputable evidence-based research.

Check for Yourself

- Use PubMed to search for and read a scientific article that involves the use of a dietary supplement to improve some facet of sports performance. To get a list of studies, you may go to www.pubmed.gov, and type in the name of the supplement and the term "exercise" in the search column, or simply scan some online sports medicine and nutrition journals. Compare the methodology to the recommended criteria presented in this section. Develop a short synopsis of the research article that you could post on a reputable sports-nutrition blog.

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APPLICATION EXERCISE

Jada is a 20-year-old college sophomore who is taking a full load of classes, volunteers at a local school about 5 hours per week, and works at the campus gym about 10 hours per week. Working at the gym has motivated Jada to train for her first 5K, which she will do in 8 weeks.

Jada works out a couple of times per week, most commonly doing fitness classes such as cardio Zumba and Pilates. She has started to walk and jog outdoors to prepare for the 5K.

In terms of her diet, Jada eats most of her meals on campus as she is a Residential Advisor in one of the dorms. She has a small refrigerator and kitchenette in her dorm suite where she can prepare meals, but she tends to eat most frequently at the dining hall.

Your Turn:

1. Use a diet analysis program, such as NutritionCalc Plus, to create a meal plan for Jada. You will need to create a profile for her. She is 20 years old, 5'8" tall, 140 lbs, engages in 30–60 minutes of moderate physical activity daily, and she would like to stay at her current weight.
2. Develop a one-day meal plan for Jada to follow. Organize the plan by meal and include specifics on the type of food/beverage and serving size.
3. What general advice do you have for Jada in terms of food and beverage items to store in her kitchenette area? List three snack options that she can take with her to eat between classes.
4. Look at reputable online sources to find training plans for a new runner who is training for a 5K. Develop that training plan into a table for Jada.

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Review Questions—Multiple Choice

1. What is the leading cause of death in the United States (2015)?
   a. heart disease
   b. diabetes
   c. cancer
   d. accidents
   e. pneumonia
2. According to the *2008 Physical Activity Guidelines for Americans*, healthy adults should engage in at least _____ minutes of moderate-intensity physical activity each week.
   a. 60
   b. 75
   c. 100
   d. 150
   e. 210
3. Which of the following is NOT a health benefit associated with engaging in regular physical activity?
   a. increased bone density and strength
   b. reduced risk for type 1 diabetes
   c. enhanced immune function
   d. reduced stress
   e. prevention of brain deterioration that occurs with aging
4. A person trying to follow the Prudent Healthy Diet recommendations might do all of the following except _____.
   a. eat only low-acid foods
   b. eat foods with less salt
   c. eat a wide variety of foods
   d. eat a diet low in saturated fat
   e. choose a diet rich in plant foods
5. Poor nutrition may contribute to the development of numerous chronic diseases. For example, obesity, high blood pressure, diabetes, and heart disease are most associated with which of the following nutritional problems?
   a. diets rich in vitamins and minerals
   b. diets rich in dietary fiber
   c. diets rich in fat and kcal
   d. diets rich in complex carbohydrates
   e. diets rich in plant proteins
6. Which of the following is considered an intermittent, high-intensity sport?
   a. marathon running
   b. Olympic weight lifting
   c. golf
   d. sprint speed skating
   e. soccer
7. Based on the *2008 Physical Activity Guidelines for Americans*, which of the following statements is false?
   a. Moderate-intensity aerobic exercise should be done for a minimum of 150 minutes each week.
   b. Vigorous-intensity exercise may be done for a minimum of 75 minutes each week.
   c. Each daily exercise bout of aerobic exercise may be done continuously or in smaller segments, such as three 10-minute bouts.
   d. In general, more is better, as exceeding the minimum recommended amounts of exercise may provide additional health benefits.
   e. Resistance exercise, including exercises for the major muscle groups in the body, is recommended at least 5, and preferably 7, days per week.
8. Which of the following statements regarding ergogenic aids is false?
   a. They are designed to enhance sports performance.
   b. Use of any aid that enhances sports performance is illegal and is grounds for disqualification.
   c. Although most nutritional ergogenics are safe, some dietary supplements pose significant health risks.
   d. Endorsement of a nutritional ergogenic by a professional athlete does not necessarily mean that it is effective as advertised.
   e. Some nutritional supplements marketed as ergogenics may contain prohibited drugs.

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9. In an experimental study to evaluate the effect of caffeine supplementation on endurance, which of the following would not be considered acceptable for the research methodology to be followed in the conduct of the study?
   a. Use well-trained power sport athletes.
   b. Use a double-blind protocol.
   c. Use a placebo control group.
   d. Use a sport-related performance task.
   e. Use participants of a similar age and training level.
10. A meta-analysis is _____.
   a. an ergogenic aid for mathematicians
   b. a technique to evaluate the presence of drug metabolites in athletes
   c. a statistical evaluation of a collection of studies in order to derive a conclusion
   d. an evaluation of the daily metabolic rate
   e. an analytical technique to evaluate biomechanics in athletes

Answers to multiple choice questions:
1. a; 2. d; 3. b; 4. a; 5. c; 6. e; 7. e; 8. b; 9. a; 10. c

Critical Thinking Questions

1. List at least eight potential health benefits of a person engaging in a regular, comprehensive exercise program. Then, describe at least two possible mechanisms by which exercise may enhance health status.
2. List two *Healthy People 2020* objectives related to physical activity and summarize the progress toward achieving those goals (www.healthypeople.gov).
3. Describe five general eating strategies that an athlete may follow to enhance sports performance.
4. Search online for a dietary supplement advertised for weight loss. Evaluate the information provided on the website for that supplement. Would you recommend this supplement to a friend? Why or why not?
5. Use an online search tool (e.g., PubMed) to find an original research study related to sports nutrition. Describe the type of research study, including the number and characteristics of participants and study design. Based on that information, evaluate the credibility of the study. Was it well designed?

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