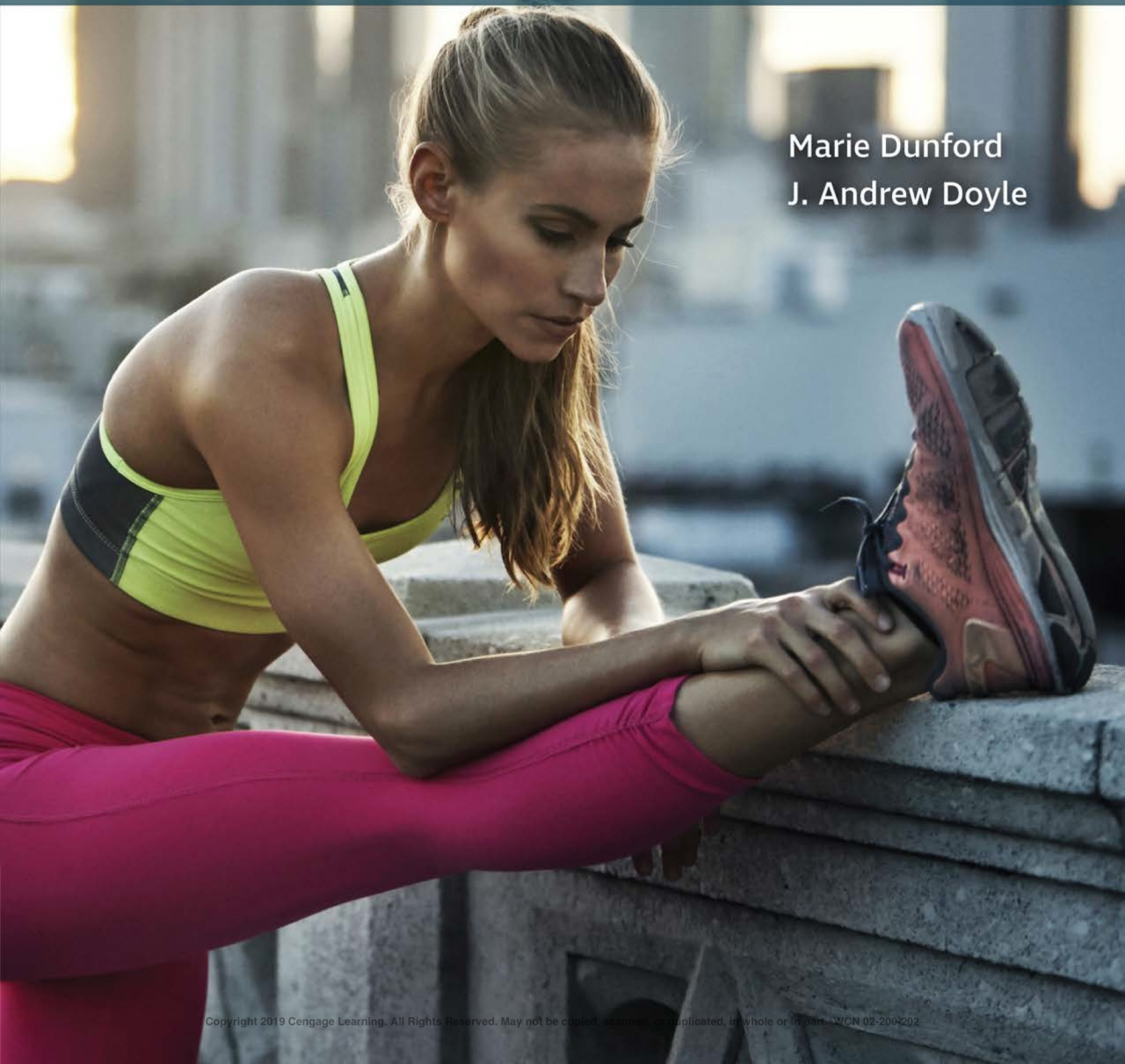




Nutrition for Sport & Exercise ^{4e}



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Nutrition

for Sport and Exercise

FOURTH EDITION

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Preface

Sports nutrition is a natural marriage of two fields: nutrition and exercise physiology. These complementary academic disciplines enable us to understand the energy expenditure that is required by exercise and sport and the energy intake that is vital to support these activities. Exercise challenges the human body to respond and adapt, and proper nutrition supports the physiological processes that make it possible to do so. Although all people can benefit from proper nutrition and exercise, athletes must pay careful attention to both. Training and nutrition are key elements of excellent athletic performance.

Nutrition for Sport and Exercise is designed primarily as a college-level text for upper-division courses in sports nutrition. It carefully illustrates the links among exercise, nutrition, and, the ultimate goals, which are recovery, optimal performance, and good health. In addition to explaining the rationale behind the recommendations made to athletes, the text helps instructors and students translate these recommendations to specific plans for the appropriate amount and type of foods, beverages, and/or supplements to support training, recovery, and performance. First and foremost, this book is scientifically sound and evidence based, but it is also filled with practical nutrition information and designed so faculty can easily teach from the text.

To understand sports nutrition, students must understand both nutrition and exercise physiology. For example, carbohydrates are found in food and are used by the body to fuel exercise. The type and amount of carbohydrates in foods are “nutrition” issues. The influences of exercise intensity and duration on carbohydrate usage are “exercise physiology” issues. Sports nutrition requires an understanding and integration of these issues because the timing of carbohydrate intake or the amount needed to delay the onset of fatigue involves both nutrition and exercise physiology. The goal of this book is to integrate the principles of nutrition and exercise physiology in a well-organized, scientifically sound, and practical sports nutrition text.

The Plan of the Text

Chapter 1, *Introduction to Sports Nutrition*, sets the stage. Broad terms such as *athlete* and *exercise* are defined, and basic training and sports nutrition

principles are outlined. The intensity and duration of exercise training and the unique demands of competition affect nutrition requirements and food intake. Many recreational athletes require only a good basic diet. Nearly all athletes have questions about supplements, and the first chapter discusses basic information about dietary supplements.

The first chapter also emphasizes the science behind sports nutrition recommendations. From the beginning, students should recognize that the recommendations made throughout the text are evidence based. As part of the critical thinking process, future chapters will reinforce some of the basic concepts introduced in the initial chapter, such as the strength of the scientific evidence, research design, and consensus opinion. Each chapter includes a *Focus on research box*, which examines a specific research study in detail. The feature provides a more in-depth look at a topic relevant to the content of the chapter and uses different types of research studies to explain scientific methods used by the researchers, what was discovered, and the significance of the research.

A unique feature of this chapter is the information on the scope of practice of dietitians, exercise physiologists, athletic trainers, strength and conditioning coaches, and other sports-related professionals. As with any integrated discipline, no one profession “owns” sports nutrition. However, the extent of professional training and licensure can help students understand practice boundaries and when to refer to someone with the appropriate expertise, professional training, and/or credentials.

Chapters 2 and 3 cover energy concepts. Extensive teaching experience has convinced us that students more easily understand the difficult area of energy when presented in a two-part approach. The first part (*Defining and Measuring Energy*) introduces general energy concepts—what energy is and how it is measured by direct and indirect calorimetry. This leads to a discussion of energy balance and an explanation of factors that affect it, such as Resting Metabolic Rate, physical activity, and food intake.

After that foundation is established, students can more easily understand the specific energy systems needed to fuel exercise of varying intensities as presented in Chapter 3, *Energy Systems and Exercise*.

The focus of this chapter is an explanation of the three major energy systems used to replenish ATP—creatine phosphate, anaerobic glycolysis, and oxidative phosphorylation. Oxygen consumption, fuel utilization, and the respiratory exchange ratio are described, and the safety and effectiveness of creatine supplements are reviewed.

Chapters 4, 5, and 6 cover three energy-containing nutrients—*Carbohydrates*, *Proteins*, and *Fats*. These topics are at the heart of sports nutrition. Each chapter includes a description of digestion, absorption, and metabolism of these nutrients and explains each as a source of energy based on the intensity and duration of exercise. Current recommendations for athletes are outlined, and the effects of inadequate intake on training, recovery, and performance are discussed. Type, amount, and timing are important nutrition concepts, and these chapters end with a focus on the translation of current recommendations to appropriate food and beverage choices.

Similar to Chapters 4 through 6, Chapters 7 through 9 are nutrient focused. *Water and Electrolytes* are covered first, followed by *Vitamins and Minerals*. These chapters feature a global approach so that students can relate to body systems that are influenced by many different factors. For example, Chapter 7 begins with an overview of water and electrolytes but emphasizes the effect that exercise has on fluid and electrolyte balance by examining water and electrolyte loss and intake during training and competition. The recommendations for replenishment of water and electrolytes are a logical extension of understanding fluid homeostasis.

To avoid the encyclopedic approach that can overwhelm students with detailed information about vitamins and minerals, Chapters 8 and 9 are organized according to function. In the case of vitamins, their major roles in energy metabolism, antioxidant protection, red blood cell function, and growth and development are explained. The minerals chapter is organized according to bone, blood, and immune system function and emphasizes calcium, iron, and zinc, respectively. Each chapter also discusses adequate intake and the potential for clinical and subclinical deficiencies and toxicities. Vitamin- and mineral-rich foods, fortified foods, and supplement sources are covered, with special attention paid to the perceived need for supplementation by athletes.

After a solid foundation in principles of sports nutrition has been laid, the text moves into comprehensive diet planning. Chapter 10 is entitled *Diet Planning: Food First, Supplements Second* and helps students take the science-based nutrient recommendations made in the previous chapters and translate them into daily food choices, including food and fluid intake prior to, during, and after exercise. The chapter emphasizes developing a plan for matching dietary intake to the demands imposed by training, with consideration for the athlete's specific sport. This chapter also contains information about caffeine, alcohol, and dietary supplements.

Supplements are a complicated issue requiring an understanding of legality, ethics, purity, safety, and effectiveness. Although most dietary supplements have not been shown to be effective, practitioners will have little credibility with athletes if they simply dismiss their use. Exploring the issues surrounding dietary supplements helps students become better critical thinkers.

No sports nutrition book would be complete without a chapter on body composition. Chapter 11, *Weight and Body Composition*, is realistic—it considers measurement techniques, error of measurement, interpretation of body composition results, and the relationship of body composition and weight to performance. The chapter begins with a review of methods for determining body composition and the advantages and disadvantages of each. The role of training and nutrition in increasing muscle mass and decreasing body fat is explained. Minimum and target body weights, based on a body composition that promotes health, are discussed for sports in which making weight or achieving a certain appearance is important. Muscle-building and weight loss supplements are also covered.

Chapter 12 covers disordered eating and exercise patterns in athletes. The philosophy expressed throughout the book is that normal eating is flexible and that food is eaten both for fuel and for fun. However, disordered eating and life-threatening eating disorders can touch the lives of anyone who works with athletes, and these problems cannot be ignored. This chapter follows the progression of eating and activity patterns from “normal” to disordered to severely dysfunctional. Low energy availability is explained and the interrelated elements of the Female Athlete Triad and the Reduced Energy Deficiency in Sport (RED-S) are discussed.

Whereas the focus in most of the chapters is on the trained athlete, the final chapter gives ample coverage to diet and exercise for lifelong fitness and health and their roles in preventing or delaying chronic disease. Many students dream of working with elite athletes, but, in reality, most will work with many people who are recreational athletes or are untrained, have relatively low fitness levels, eat poorly, and want to lose weight. This chapter addresses the issue of declining physical activity associated with aging and uses scenarios of former athletes to highlight chronic diseases such as obesity, type 2 diabetes, heart disease, metabolic syndrome, osteoporosis, and lifestyle-related cancers. The chapter has been organized to reflect the primary role that overweight and obesity play in the development and progression of many chronic diseases. It also explains the many mechanisms, some of which are not precise, that the body uses to regulate body weight.

Nutrition for Sport and Exercise is a blend of nutrition and exercise physiology and both scientific and practical information. It fully integrates both fields of study. It is not an exercise physiology book

with nutrition as an afterthought or a nutrition book with superficial explanations of core exercise physiology principles. The authors, a registered dietitian and an exercise physiologist, have more than 45 years of classroom experience in sports nutrition. They have used that experience to create a text that meets the needs of both nutrition and exercise science majors and faculty.

Features of the Text

Each chapter is designed to guide students through the learning process, beginning with **Learning Objectives** for students to master as they study the material. A **Pre-Test** helps to assess students' current knowledge of the topic to be discussed. At the end of each chapter, a **Post-Test** is given to test what students have learned. The answers to the **Post-Test** found in Appendix O are used to illuminate misconceptions about the topic as well as to pinpoint material that warrants further study.

Glossary terms are highlighted throughout the chapters, giving students immediate access to their definitions as well as helping them identify important terms to study as they prepare for exams. The definitions have also been gathered into an alphabetical glossary at the back of the book.

Numerous sidebars appear throughout the text, exposing students to high-interest information on diverse topics. The sidebars highlight applications of concepts, present the latest findings, and point out controversial ideas without interrupting the flow of the text. Selected **Spotlight features** highlight important websites that students can trust to find information on each topic.

Every chapter has a **Focus on research** feature. This feature walks the reader through a published research study, discussing the specific purpose of the study, what the researchers did, what they found, and the significance of their findings. Readers are introduced to different types of research studies; exposed to both current research and classical, historical studies in the topic area of each chapter; and given examples of how to clearly and concisely summarize and apply research in the field.

Each chapter ends with a **Summary** that restates the major ideas, and a **Self-Test** is provided, which includes multiple-choice, short-answer, and critical thinking questions, so students can test their knowledge of the facts and concepts presented. The answers to the multiple-choice questions can be found in Appendix O. **References** for the major articles discussed throughout the chapter as well as suggested readings are available online. All of these features are designed with the student in mind, to help him or her identify and grasp the important concepts presented in each chapter.

New to the Fourth Edition

The fourth edition of *Nutrition for Sport and Exercise* includes a thorough review of the most recent published literature so that the material included in the textbook represents the most current, cutting-edge scientific information, up-to-date guidelines, and evidence-based recommendations.

Learning objectives have been closely matched with major headings and multiple-choice questions to help students recognize and learn the major concepts of each chapter. Current guidelines and position papers appear throughout, including the 2015–2020 Dietary Guidelines and the 2016 Nutrition and Athletic Performance position paper. The analysis of a 24-hour diet of a male collegiate cross-country runner, which is used as an example throughout the text, has been updated to make it easier to compare goals with intake. Other new or updated content includes the following:

Chapter 1: Introduction to Sports Nutrition

- Inclusion of the 2015–2020 Dietary Guidelines
- Inclusion of My Plate, My Wins, which helps consumers implement the 2015–2020 Dietary Guidelines
- Inclusion of the updated Nutrition Facts food label
- Updated basic sports nutrition guidelines based on the 2016 *Nutrition and Athletic Performance* position paper published by the Academy of Nutrition and Dietetics (AND), Dietitians of Canada (DC), and the American College of Sports Medicine (ACSM)
- Updated information on purity, effectiveness, certification programs, and use of dietary supplements among athletes
- Up-to-date requirements for exercise and nutrition credentials and certifications

Chapter 2: Defining and Measuring Energy

- New Spotlight on wearable fitness/activity tracking devices
- New graphics/images of new technology for tracking fitness and activity
- New section added on technological advances and devices for tracking activity, fitness, and energy expenditure
- Updated and revised section about self-reported dietary and energy intake
- Updated references and revised section about portable metabolic measurement systems

Chapter 3: Energy Systems and Exercise

- Updated references and revised Spotlight on creatine loading and supplementation
- Updated references and revised Spotlight on alcohol metabolism
- Updated glossary
- Updated images

Chapter 4: Carbohydrates

- Updated Spotlight on glycemic index
- New Focus on Research article
- Updated information about training in a low carbohydrate state
- Complete revision of the Carbohydrate Recommendations for Athletes section to reflect the AND, DC, and ACSM 2016 *Nutrition and Athletic Performance* position paper and other recent research
- Updated carbohydrate product information throughout the chapter
- Expanded section on the use of the carbohydrate mouth-rinsing strategy during exercise
- Updated Spotlight on sports drinks, bars, and gels
- New section on refueling between exercise sessions
- Updated Spotlight on a real athlete: Lucas, a Cross-Country Runner
- Inclusion of information from the 2015 *Academy of Nutrition and Dietetics Health Implication of Dietary Fiber* position paper
- Additional information about vegan foods and gluten-free foods
- New section and table explaining fermentable carbohydrates (FODMAP)
- Addition of a section on gluten intolerance

Chapter 5: Proteins

- Addition of digestible indispensable amino acid score (DIAAS) method to determine protein quality
- Streamlined metabolism section
- Consolidation of immune system material into two distinct sections
- Complete revision of the Protein Recommendations for Athletes section to reflect the 2015 *Nutrition and Athletic Performance* position paper and other recent protein research
- Incorporation of information unique to body builders into the Protein Recommendations for Athletes section
- Updated Focus on research
- Reorganization of the Protein Recommendations for Athletes section to reflect the focus on protein quantity, quality, dose (per meal), and distribution across the day
- Updated information regarding the use of higher protein intake to try to offset loss of muscle mass while restricting energy intake (“dieting”)
- Consolidation and expansion of material on vegetarian and vegan diets and inclusion of the 2016 *Academy of Nutrition and Dietetics* position paper on vegetarian diets
- Revision of the Spotlight on a real athlete feature to reflect issues related to the dose and distribution of protein across the day

- Updated product information of selected protein supplements
- Revision of the beta-alanine supplements section to reflect new evidence of effectiveness
- Revision of amino acid supplement information to reflect recent research findings

Chapter 6: Fats

- Complete revision to reflect the 2015 *Nutrition and Athletic Performance* position paper and other recent research
- Updated Spotlight on *trans* fatty acids
- Updated images
- Revised section on training with high-fat, low-carbohydrate diets
- Revised to reflect Dietary Guidelines for Americans 2015–2020
- Addition of new Nutrition Facts label
- Revision of table of total and saturated fat content of selected snack foods
- Updated Spotlight on a real athlete

Chapter 7: Water and Electrolytes

- Complete revision to reflect the 2015 *Nutrition and Athletic Performance* position paper and other recent research
- Updated graphics
- Updated table on sodium-containing products
- Updated table on composition of various pre-exercise beverages
- Updated table on composition of various beverages consumed during exercise
- Updated table on composition of various beverages consumed post-exercise
- Revised and updated section on hyponatremia
- Revised and updated section on glycerol hyperhydration

Chapter 8: Vitamins

- Updated summary charts of fat- and water-soluble vitamins, including information about cell signaling and gene expression
- New chart reflecting the probability of adequate vitamin intake for adults based on information in the 2015–2020 Dietary Guidelines
- Revised and updated Focus on research
- Updated and revised information about vitamin D, especially its role in athletic performance
- Streamlined the section about developing toxicities
- Updated and revised the sections about antioxidant vitamin supplements and performance and antioxidant vitamins and health
- Revised and updated Spotlight on antioxidant vitamins and health

- Revised Spotlight on supplements
- Complete revision of the material about quercetin
- Updated product information to reflect current formulations
- Revised section on high-potency vitamin supplements

Chapter 9: Minerals

- Updated summary charts of all minerals
- New chart reflecting the probability of adequate mineral intake for adults based on the 2015–2020 Dietary Guidelines
- Revised incidence and prevalence figures for diseases such as osteoporosis and iron deficiency anemia
- Reorganized and updated the section on iron, particularly iron deficiency and iron deficiency anemia in athletes and the effect that each may have on performance
- Revised the material on minerals involved in the immune system
- Fine-tuned the section on mineral supplementation, including chromium

Chapter 10: Diet Planning: Food First, Supplements Second

- Added new section featuring currently popular diets among athletes, such as the “Paleo” Diet and gluten-free diet for nonceliacs
- Inclusion of the 2015–2020 Dietary Guidelines and the Healthy U.S.-Style Eating Patterns
- Updated recommendations for food and fluid intake prior to, during, and after exercise
- Updated caffeine information
- Considerable revision of the alcohol section, including updated prevalence of alcohol intake by athletes, reasons why athletes consume alcohol, and effects of alcohol on training, recovery, performance, and health
- Updated table on safety and effectiveness of 27 dietary supplements commonly used by athletes
- Updated Dietary Supplement Label information
- Updated Focus on Research feature based on the AND, DC, and ACSM 2016 *Nutrition and Athletic Performance* position paper
- Expanded the section on probiotics
- Revised the last section, A Comprehensive Nutrition Plan to Support Training and Performance, by adding a four-step process (assessment, goal-setting, action plan, and evaluation and reassessment) to create a nutrition plan, which is illustrated in the accompanying case study (Spotlight on a real athlete)
- Replaced more than 50 percent of the references cited in the 3rd edition

Chapter 11: Weight and Body composition

- Revised section on BMI and athletes
- Updated section and references on DEXA
- Updated section and references on advanced imaging techniques used for assessment of body composition
- Updated images
- Reorganization and revision of section on height, weight, body size, and body composition in athletes
- Revised section on body weight and composition goals
- Revised Application exercise
- Incorporation of new evidence on weight cycling
- Updated Spotlight on finding reliable information about body composition and body weight

Chapter 12: Disordered Eating and Exercise Patterns in Athletes

- Updated Learning Objectives
- Revisions to the case study to acknowledge the role social media may play
- New subsection on obsessive-compulsive disorders intertwined with disordered eating with updated information about orthorexia nervosa and muscle dysmorphia
- Revised section and updated references on exercise dependence and excessive exercise
- New table with validated instruments for assessing exercise dependence, exercise addiction, and pathological exercise
- Updated information on disordered eating and eating disorders in athletes, including new material about male athletes
- Revised table on sports and activities at high risk for development of eating disorders
- Significant revisions to the section formerly named Female Athlete Triad by focusing on low energy availability, which includes the energy availability formula
- Retained information about the Female Athlete Triad, explained the Reduced Energy Deficiency in Sport (RED-S), and added discussion of controversies regarding the two models
- Revised Spotlight on finding reliable information about low energy availability

Chapter 13: Diet and Exercise for Lifelong Fitness and Health

- Updated information regarding elite male athletes, development of chronic disease, and life expectancy as they age
- Updated the Dietary Guidelines and the American Heart Association guidelines

- Revised the leading and actual causes of death figures to reflect recent statistics
- Updated information (appetite regulation signals and obesity-promoting gut bacteria) and figure about the regulation of body weight
- Updated table of comparison of weight-loss plans with current program information for Atkins, Ornish, and Weight Watchers diets
- Updated new prevalence information for Spotlight features on Type 2 diabetes, heart disease, metabolic syndrome, and osteoporosis

Appendices

- New Appendix B entitled Healthy U.S.-Style Pattern: Recommended Intake Amounts
- New Appendix C entitled Healthy Vegetarian Pattern: Recommended Intake Amounts

Instructor and Student Resources

Instructor Companion Site

Everything you need for your course is in one place! This collection of book-specific lecture and class tools is available online at www.cengage.com. Access and download PowerPoint presentations, images, instructor's manual, and more.

Nutrition MindTap

The Nutrition for Sport and Exercise MindTap brings course concepts to life with interactive learning, study, and exam preparation tools that support the printed textbook. The MindTap includes an interactive eReader, and interactive teaching and learning tools, including quizzes, flashcards, and more. It also contains built-in metrics tools that monitor student engagement in the course.

Test Bank

Powered by Cognero, the Test Bank is a flexible, online system that allows instructors to author, edit, and manage test bank content from multiple Cengage Learning solutions; create multiple test versions in an instant; and deliver tests from your Learning Management System (LMS), your classroom, or anywhere you want.

Diet & Wellness Plus

Take control. Reach your goals. Experience Diet Analysis Plus. Diet Analysis Plus allows students to track their diet and physical activity, and analyze the nutritional value of the food they eat so they can adjust their diets to reach personal health goals—all while gaining a better understanding of how nutrition relates to and impacts their lives. Diet Analysis Plus includes a 55,000+ food database; customizable

reports; new assignable labs; custom food and recipe features; the latest Dietary Reference Intakes; and goals and actual percentages of essential nutrients, vitamins, and minerals. New features include enhanced search functionality with filter option, easy-to-use instructor page, and resources tab with helpful information.

Acknowledgments

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We are particularly appreciative of those who reviewed the text. Their time, effort, and suggestions have helped make this a much better book. We appreciate your insights and your suggestions.

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In addition to our appreciation of the work done by our editorial and production teams, each of us wishes to express special thanks as follows:

MD: This book actually began in the 1980s, although I didn’t know it at the time, when some insightful

faculty at California State University, Fresno, supported the development of a new course—Nutrition and the Athlete. The course evolved over the many years that I taught it and continues to go strong after 30 years. I also met Andy Doyle during this time, a fellow member of the faculty, who is a wonderful coauthor. I thank him for adding his considerable expertise to this book, bringing the best out in me, and always maintaining his sense of humor despite crazy deadlines.

It takes many years to write the first edition of a textbook, and it is such an arduous task that it would not be possible without support from family, friends, and colleagues. It is a thrill to revise and write the fourth edition, but it is no less of an arduous task. Heartfelt thanks goes to all the reviewers and colleagues who made suggestions. There are too many to mention by name but I am most appreciative to all who have encouraged me over the course of my career.

JAD: I would like to thank my coauthor, Marie, for inviting me along on this wonderful, crazy journey. I particularly appreciate her patience, persistence, discipline, and good humor. My wife, Colleen, my sons, Patrick and Jackson, and my sister, Liz Doyle, have always been supportive of my education and my career, and I would like to thank them for their love and support. They have been very patient and supportive when this project has demanded a lot of my time and attention. Thank you to Colleen also for reviewing Chapter 13 from her perspective as the Director of Nutrition and Physical Activity for the American Cancer Society. Many thanks are due also to the students who have been an integral part of my courses and research over the years. Their curiosity, questions, and comments have inspired me to continue to grow and develop as a teacher. Finally, I would like to thank the faculty and staff of the Department of Kinesiology and Health at Georgia State University for their support.

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Marie Dunford, Ph.D., R.D., has been involved in sports nutrition since the mid-1980s. In 1985, while a faculty member at California State University, Fresno, she created the curriculum for an upper division course entitled, *Nutrition and the Athlete*. She taught the course for a total of 16 years during which she interacted with thousands of student-athletes. This direct exposure to nutrition and exercise science majors and

NCAA Division I athletes helped her to develop an understanding of how students learn and the sports nutrition topics that are most difficult for students to master. In addition to this textbook, Dr. Dunford has written three other books—*Fundamentals of Sport and Exercise Nutrition*, *The Athlete's Guide to Making Weight: Optimal Weight for Optimal Performance*, and *Nutrition Logic: Food First, Supplements Second*—and numerous online sports nutrition courses for nutrition and exercise professionals. She is a member of Sports, Cardiovascular, and Wellness Nutritionists (SCAN), a dietetic practice group of the Academy of Nutrition and Dietetics. She is also an avid recreational tennis player.



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Ohio State University. He has taught exercise physiology, exercise testing and fitness assessment, and exercise programming at the undergraduate and graduate level for more than 25 years. His research interests include carbohydrate metabolism and exercise and the role of physical activity, exercise, and fitness in health. He has conducted, published, and presented numerous research studies with cyclists, runners, and triathletes, and he has extensive experience testing elite athletes from cycling, running, gymnastics, rowing, canoe and kayak, and basketball. Dr. Doyle is a Fellow of the American College of Sports Medicine. He is an avid Atlanta Braves fan, and now retired from coaching youth basketball and baseball he will have more time for golf, hiking, and cycling.

To my husband, Greg. *C'est le ton qui fait la chanson*. It's the melody that
makes the song.
MD

In memory of my mother, Ann Shiver Lundquist.
JAD

Introduction to Sports Nutrition

1

Learning Objectives

LO 1.1 Explain the need for an integrated training and nutrition plan.

LO 1.2 Explain basic nutrition principles and how they might be modified to meet the needs of athletes.

LO 1.3 List sports nutrition goals.

LO 1.4 Outline the basic issues related to dietary supplements and ergogenic aids, such as legality, ethics, purity, safety, and effectiveness.

LO 1.5 Distinguish between types of research studies, weak and strong research designs, and correlation and causation.

LO 1.6 Compare and contrast the academic training and experience necessary to obtain various exercise and nutrition certifications.

Proper nutrition supports training, performance, and recovery.



Patrick Giordano/Getty Images

PRE-TEST

Assessing Current Knowledge of Sports Nutrition

Read the following statements, and decide if each is true or false.

1. An athlete's diet is a modification of the general nutrition guidelines made for healthy adults.
2. After a healthy diet plan is developed, an athlete can use it every day with little need for modification.
3. In the United States, dietary supplements are regulated in the same way as over-the-counter medications.
4. The scientific aspect of sports nutrition is developing very quickly, and quantum leaps are being made in knowledge of sports nutrition.
5. To legally use the title of sports nutritionist in the United States, a person must have a bachelor's degree in nutrition.

Welcome to the exciting world of sports nutrition. This relatively new field is a blend of nutrition and exercise physiology. These fields are complementary academic disciplines that help us understand the energy expenditure that is required by exercise and sport, as well as the energy and nutrient intake that is vital to support excellent **training**, **recovery**, and performance. Exercise and sport challenge the human body to respond and adapt, and proper nutrition supports these processes. Training and nutrition are keys to athletic performance at any level. The Olympic motto is *Citius, Altius, Fortius*, which is Latin for “swifter, higher, stronger.” To achieve the highest level of success, athletes must be genetically endowed, and they must train optimally to meet their genetic potential. Proper nutrition supports the demands of training, and the field of sports nutrition emerged to help athletes train, perform, and recover to the best of their abilities. To run faster, jump higher, and be stronger, athletes must use genetics, training, and nutrition to their advantage.

1.1 Training, Nutrition, and the Athlete

LO 1.1 Explain the need for an integrated training and nutrition plan.

Sports nutrition is a blend of exercise physiology and nutrition

Exercise physiology is the science of the response and adaptation of bodily systems to the challenges imposed by movement—physical activity, exercise, and sport. Nutrition is the science of the ingestion, digestion,

absorption, metabolism, and biochemical functions of nutrients. **Sports nutrition** is the integration and application of scientifically based nutrition and exercise physiology principles that support and enhance training, performance, and recovery. These principles also help athletes attain and maintain good health.

First and foremost, these disciplines are based on sound scientific evidence. But there is also an art to applying scientific principles to humans. For example, scientists identify nutrients found in food that are needed by the body, but food is sometimes eaten just because it tastes delicious or smells good. Exercise physiologists know from well-controlled research studies that the size and strength of athletes' muscles can be increased with overload training, but choosing the appropriate exercises, the number of sets and repetitions, the amount of resistance, the rest intervals, and the exercise frequency for optimal response by each individual athlete is as much an art as it is a science. Because sports nutrition is a relatively young field, the knowledge base is continually expanding, and our understanding of the field is constantly evolving. There is more research to be done and much more to be learned, presenting an exciting opportunity for exercise science- and nutrition-oriented students.

The term *athlete* is very broad and inclusive

The word *athlete* describes a person who participates in a sport. Using that definition, professional, collegiate, and weekend basketball players are all athletes (Figure 1.1). Clearly there are differences among them. One difference is skill, and another is training. Elite athletes are exceptionally skilled and dedicated to their training regimens. Their lives are planned around their training and competition schedules because athletic competition is their profession.



FIGURE 1.1 Anyone who participates in a sport can be called an athlete. As a means of distinction, the terms *elite athlete*, *well-trained athlete*, and *recreational athlete* are often used.

Collegiate athletes are also trained athletes, although the level of their training is probably less than that of their professional counterparts. Dedication to training is important because proper training is necessary to improve or maintain performance. Many people are recreational athletes. Some of them are former competitive athletes who continue to train, albeit at a lower level, to remain competitive within their age group or in masters events. They are sometimes referred to as performance-focused recreational athletes. However, many recreational athletes train little, if at all, and their primary focus is not improving performance. They participate in sports to be physically active, to maintain a healthy lifestyle, and for enjoyment.

Physical activity, exercise, and sport differ from each other

Physical activity is bodily movement that results in an increase in **energy** expenditure above resting levels. Examples can include activities of daily living such as bathing, walking the dog, raking leaves, or carrying bags of groceries. Exercise and sport are very specific types of physical activity. Exercise has been defined as “physical activity that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is the key” (Caspersen, Powell, and Christensen, 1985). For example, running is a specific type of physical activity that is often done regularly by people who hope to improve their **cardiovascular fitness**. Sports can be thought of as competitive physical activities. Track, cross country, or road running (for example, marathon) are examples of running as a sport.

Exercise may be described as **aerobic** or **anaerobic**. Aerobic means “with oxygen” and is used in reference to exercise or activity that primarily uses the oxygen-dependent energy system—oxidative phosphorylation (Chapter 3). These types of activities can be sustained for a prolonged period of time and are referred to as endurance activities. Those who engage in them are referred to as endurance athletes. Some endurance athletes are better described as ultraendurance athletes because they engage in sports that require hours and hours of continuous activity, such as triathlons. Endurance and ultraendurance athletes are concerned about the same issues, such as adequate carbohydrate and fluid intake, but there are enough differences between them that their concerns are often addressed separately.

Training: A planned program of exercise with the goal of improving or maintaining athletic performance.

Sports nutrition: The application of nutrition and exercise physiology principles to support and enhance training, performance, and recovery.

Recovery: An undefined period of time after exercise for rest, replenishment, and adaptation.

Energy: The capacity to do work. In the context of dietary intake, energy is defined as the caloric content of a food or beverage.

Cardiovascular fitness: Ability to perform endurance-type activities, determined by the heart’s ability to provide a sufficient amount of oxygen-laden blood to exercising muscles and the ability of those muscles to take up and use the oxygen.

Aerobic: “With oxygen.” Refers to exercise that primarily uses the oxygen-dependent energy system, oxidative phosphorylation.

Anaerobic: “Without oxygen.” Refers to exercise that primarily uses one or both of the energy systems that are not dependent on oxygen, creatine phosphate or anaerobic glycolysis.



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FIGURE 1.2 Although each participates in the same sport, the training and nutritional needs of recreational and elite athletes are very different.

Anaerobic means “without oxygen” and refers to exercise that primarily uses one or both of the energy systems that are not dependent on oxygen—creatine phosphate or anaerobic glycolysis (Chapter 3). These types of activities are short in duration and high in exercise **intensity**. Athletes in high-intensity, short-duration sports are often called strength athletes or strength/power athletes. Although few sports are truly anaerobic, and weight lifting to strengthen muscles is usually a part of an endurance athlete’s training, strength athlete and endurance athlete are terms that are commonly used.

Training and nutrition go hand in hand

The longtime columnist, book author, and running philosopher George Sheehan (1980) once wrote that everyone is an athlete; only some of us are not in training. Athletes improve their sports performance through skill development and training. Skill development is enhanced through practice and instruction or coaching. Success in many sports is directly related to fitness levels achieved by sport-specific training. For example, to be successful, competitive distance runners must have a high level of cardiovascular fitness, which is developed through following a rigorous running training program.

As advances in exercise and sports science have become more widely recognized and adopted, athletes from a wide variety of sports have begun to use improved physical conditioning as a way to further improve their performance. Even athletes in sports such as golf and auto racing have begun physical training as a strategy to improve personal performance. Physical training to improve specific components of fitness must be taken into account when considering nutritional needs, such as total energy and carbohydrate intakes. Nutrition supports training and good health—two factors that are essential to excellent performance.

Although nutrition by itself is important, it may have the greatest performance impact by allowing athletes to train consistently. Proper nutrition during the recovery period is essential for replenishing nutrient stores depleted during training, for example, muscle **glycogen**. Inadequate replenishment of energy, fluid, carbohydrates, proteins, and/or vitamins and minerals limits the potential for full recovery after training. Limited recovery can result in **fatigue** during the next training session, and consistent lack of nutritional replenishment can lead to **chronic** fatigue (Thomas, Erdman, and Burke, 2016). Although the basic nutrition principles are the same for well-trained and recreational athletes, the specific nutrient needs will depend on the intensity and duration of training (Figure 1.2).

Athletes perceive that nutrition is important, but they sometimes fail to realize or acknowledge that it is a factor that needs daily attention. This often leads to **crash diets** and other quick fixes, which may interfere with training and undermine performance and recovery. Nutrition and training are similar in that each is a process that needs a well-developed plan (Dunford and Macedonio, 2017).

Athletes can also get so focused on one small aspect of their diet that they neglect their comprehensive daily nutrition requirements. For example, athletes may concentrate on the best precompetition meal, but if they fail to address their day-to-day nutrition needs, then their training will suffer. Inadequate training that is a result of inadequate nutrient replenishment is much more detrimental to performance than the precompetition meal is beneficial to performance (Thomas, Erdman, and Burke, 2016).

Nutrition supports training, recovery, and performance

The main goal for any competitive athlete is to improve performance. Improvements in sport performance can