

Nutrition for Sport and Exercise

Second Edition



Marie
Dunford

J. Andrew
Doyle

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Marie Dunford

Former Professor and Chair

Department of Food Science and Nutrition

California State University, Fresno

J. Andrew Doyle

Associate Professor and Former Chair

Department of Kinesiology and Health

Georgia State University



**Nutrition for Sport and Exercise,
Second Edition**

Marie Dunford

J. Andrew Doyle

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Senior Acquisitions Editor: Peggy Williams

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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 these processes. 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 between exercise, nutrition, and, the ultimate goals, optimal performance and 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, performance, and recovery. 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 new feature, *Focus on research*, 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 the authors that students more easily understand the difficult area of energy if it is broken into two parts. 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.

Once that foundation is established, then 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 the 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 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, and 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 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, and explains the inter-related elements of the Female Athlete Triad.

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 35 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 a **Learning Plan** that lists 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* can be found in Appendix O, and used to illuminate misconceptions about the topic as well as to pinpoint material that warrants further study.

Glossary terms are highlighted throughout the chapter, 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. **The Internet café** highlights important websites that students can trust to find information on each topic.

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 included, so students can further investigate topics on their own. 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 Second Edition

The second 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.

Three new features were added to each chapter. **Focus on research** is designed to help students understand research methods and results and the significance and application of those results. The studies chosen reflect a topic covered in the chapter and help students see how research and practice are related. The **Application exercise** gives students a brief scenario, along with questions, and encourages them to apply the information that they have read. **Key points** and review questions at the end of each major section assist students in identifying the important information

from that section and test their mastery of that information. Other new or updated content includes:

Chapter 1: Introduction to Sports Nutrition

- Dietary Guidelines for Americans, 2010
- Physical Activity Guidelines for Americans, 2008
- Food Pyramid for Athletes
- More information about the Nutrition Facts label
- Expanded section on dietary supplements, including why athletes choose supplements, issues related to purity, and a summary of supplements that have been shown to be safe and effective

Chapter 2: Defining and Measuring Energy

- Updated graphics and artwork
- Expanded discussion of measurement of energy expenditure with wearable, portable devices
- Updated section on estimating energy intake
- Revised section on estimating energy expenditure of individual physical activities
- Enhanced table for estimating daily energy need for male and female athletes

Chapter 3: Energy Systems and Exercise

- Updated, reorganized, and streamlined graphics and artwork
- Expanded review of high-energy phosphate use by exercising skeletal muscle
- Updated discussion of ATP yield from oxidative phosphorylation
- Updated discussion of creatine loading and supplementation
- Reorganized and expanded discussion of metabolism and fuel utilization
- New chart summarizing effects of feeding and fasting on metabolic pathways
- Expanded section on oxygen consumption and skeletal muscle fiber types

Chapter 4: Carbohydrates

- Updated and improved graphics
- Reorganized and expanded section on digestion and absorption of carbohydrates, with particular emphasis on glucose and fructose transport
- New graphic on carbohydrate absorption
- Updated information and discussion on glycemic index
- Expanded section on carbohydrate metabolism and exercise training
- Expanded and updated section on carbohydrate use before, during, and after exercise
- New table outlining optimal carbohydrate intake during various types of exercise and sports
- New tables detailing the characteristics of the most current sports carbohydrate products
- Discussion of carbohydrate products developed and marketed for use by athletes in various sports and exercise situations

Chapter 5: Proteins

- Extensive revision of pre-, during, and postexercise protein recommendations
- More information about whey and casein
- Expanded section on the role of protein in the immune system and the impact of endurance exercise
- Explanation of how amino acids act as regulators of critical metabolic pathways
- Sidebar that explores the strategies used by some athletes to maximize skeletal muscle mass
- Expanded section on protein and amino acids supplements, including summary table of safety and effectiveness. New supplements include beta-alanine, growth hormone releasers, and nitric oxide

Chapter 6: Fats

- More information on *trans* fats and omega-3 fatty acids
- Discussion of the role that omega-3 fatty acids in foods and as supplements may play in offsetting acute inflammation and chronic immune dysfunction
- Updated caffeine recommendations for athletes

Chapter 7: Water and Electrolytes

- Added information on water content of various beverages
- New information and table on electrolytes
- Enhanced information on hyponatremia
- Updated discussion on exercise-associated muscle cramping
- Updated information and table on sodium-containing products
- New tables detailing the composition of various pre-exercise beverages, and beverages used during and after exercise
- Updated, reorganized, and expanded section on fluid intake strategies before, during, and after exercise
- Updated and reorganized section on individualized planning to meet fluid and electrolyte needs

Chapter 8: Vitamins

- New section added on the function of vitamins in growth and development
- Substantial amount of material added about vitamin D, including the 2010 revisions to the DRI
- Added information about quercetin

Chapter 9: Minerals

- Chapter reorganization to match the organization of the vitamin chapter, to the extent possible
- Expansion and reorganization of the section on the role of minerals in bone formation
- New information about average daily calcium intake and inclusion of the 2010 revisions to the DRI for calcium and vitamin D
- User-friendly chart explaining iron-related blood tests

Chapter 10: Diet Planning: Food First, Supplements Second

- Updated estimate of daily energy need for male and female athletes
- Explanation of the role that solid fats and added sugars (SoFAS) play
- Completely revised sections on food and fluid intake before, during, and after exercise
- Updated and expanded section on caffeine
- Table summarizing the safety and effectiveness of more than 20 dietary supplements

Chapter 11: Weight and Body Composition

- Graphics and artwork updated and streamlined for improved readability
- Updated information on body fat ranges for athletes in selected sports
- Updated references for norms for body composition
- Revised and expanded section on the relationship of body composition and weight to athletic performance
- Updated section on changing body composition to enhance performance with new research
- Reorganized discussion of weight certification in sports
- Revised and updated section on supplements used to change body composition
- New section on the supplement bitter orange

Chapter 12: Disordered Eating and Exercise Patterns in Athletes (*New Chapter Order*)

- Updated incidence and prevalence statistics
- Updated information on the Female Athlete Triad, including the American College of Sports Medicine position paper issued in 2007

Chapter 13: Diet and Exercise for Lifelong Fitness and Health (*New Chapter Order*)

- Updated guidelines including Dietary Guidelines for Americans, 2010, and Physical Activity Guidelines for Americans, 2008
- Repositioning and expanding the section on overweight and obesity to better illustrate the fundamental role of weight in chronic-disease prevention and treatment
- More information about childhood and adolescent obesity
- New section about how the body regulates weight
- Updates on all chronic diseases, including hypertension, diabetes, heart disease, metabolic syndrome, osteoporosis, and lifestyle-related cancers
- Information about the role that solid fats and added sugars (SoFAS) play in chronic disease, particularly heart disease
- Added section on the role of population-level changes that may help to initiate or sustain individual behavior changes

Appendixes

- The DASH (Dietary Approaches to Stop Hypertension) Eating Plan updated with 2010 Dietary Guidelines for Americans information
- New USDA Food Patterns including lacto-ovo vegetarian and vegan adaptations
- U.S. Food Exchange System updated to 2008 edition
- New step-by-step directions, enhanced equations, and clear examples for determining energy expenditure rate and total energy expenditure for specific physical activities from the Compendium of Physical Activities
- Updated normative percentile values for maximal oxygen consumption for men and women
- Updated detailed graphics for glycolysis, the Krebs cycle, the electron transport chain, and β -oxidation
- NCAA bylaw on use of banned drugs updated to 2010–11 version
- Updated normative percentile values for percent body fat for males and females

Instructor and Student Resources

PowerLecture

This convenient tool makes it easy for instructors to create customized lectures. Each chapter includes the following features, all organized by chapter:

- Lecture slides
- All chapter art and photos
- Animations and videos
- *Instructor's Manual*, featuring summaries of chapter concepts, chapter outlines, and suggested activities and assignments
- *Test Bank*, including more than 1,400 questions in multiple-choice, true/false, matching, fill-in-the-blank, and essay formats
- *ExamView*® testing software preloaded with the Test Bank items

This single disc places all the media resources at your fingertips.

Nutrition CourseMate

Cengage Learning's Nutrition CourseMate brings course concepts to life with interactive learning, study, and exam preparation tools that support the printed textbook, or the included eBook. With CourseMate, professors can use the included Engagement Tracker to assess student preparation and engagement. Use the tracking tools to see progress for the class as a whole or for individual students. Students can access an interactive eBook, chapter-specific interactive learning tools, including flashcards, quizzes, videos, and more in their Nutrition CourseMate, accessed through **CengageBrain.com**.

Diet Analysis+

We have updated *Diet Analysis+*, the market-leading diet assessment program for Nutrition, to make it

more useful for Exercise and Health Science courses. The user can easily create a personalized profile based on height, weight, age, sex, and activity level, including additional features to measure body frame, BMI, girth in centimeters, skinfold in millimeters, and exercise and resting heart rates. Its dynamic interface makes it easy to track calories, carbohydrates, fiber, proteins, fats, vitamins, and minerals in foods, as well as determine whether nutrient needs are being met. The program's Enhanced Search functionality allows users to filter food by category—improving search precision and making it easier to find certain foods.

Global Nutrition Watch

Updated several times a day, Global Nutrition Watch is an ideal resource for classroom discussion and research projects. You and your students get access to information from trusted academic journals, news outlets, and magazines, as well as videos, primary sources, podcasts, and much more.

Walk4life Elite Model Pedometer

This pedometer tracks steps, elapsed time, distance, and calories expended. The pedometer includes an extra-large digital display with a hinged protective cover, and comes with instructions outlining how to use the tool most effectively. It can be used as part of an in-class activity or as a tool to increase awareness and encourage students to simply track their steps and walk toward better fitness. This is a valuable resource for everyone, and at \$15 when bundled with the text, this pedometer is a deal!

Acknowledgments

From initial conceptualization to final product, this book, and now the second edition, has required several years and the efforts and inspiration of many people. The authors would like to thank those people, both together and individually, who have either directly or indirectly helped make this book a reality.

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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.

Reviewers

Second Edition

Dawn E. Anderson, *Winona State University*
 Kathleen M. Laquale, *Bridgewater State University*
 Rebecca Mohning, *George Washington University*
 Dave Pavlat, *Central College*
 Kimberli Pike, *Ball State University*
 Jack L. Smith, *University of Delaware*
 Stacie L. Wing-Gaia, *University of Utah*

First Edition

Charles Ash, *Kennesaw State University*
 John Bergen, *University of West Florida*
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 Joseph Chromiak, *Mississippi State University*
 Kristine Clark, *Penn State University*
 Edward Coyle, *University of Texas, Austin*
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 Joanne Slavin, *University of Minnesota*
 Teresa Snow, *Georgia Institute of Technology*
 Tom R. Thomas, *University of Missouri*
 Helen Ziraldo, *San Jose State University*

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, in large part due to feedback from students, and I would like to thank them for challenging me to be a better teacher. I also met Andy Doyle during this time, a fellow member of the faculty, who is a wonderful co-author. I thank him for adding his considerable expertise to this book, bringing the best out in me, and always maintaining his sense of humor.

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 second 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 co-author, Marie, for 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. Many thanks are due also to the students who have been an integral part of my courses and research over the years. In particular, I'd like to thank Ryan Luke for his research assistance on this book, and Rob Skinner for the many conversations we've had in which he has shared his ideas and experience in sports nutrition. Finally, I would like to thank the faculty and staff of the Department of Kinesiology and Health at Georgia State University for their support.

Marie Dunford, Ph.D., R.D.
 Former Professor and Chair
 Department of Food Science and Nutrition
 California State University, Fresno

J. Andrew Doyle, Ph.D.
 Associate Professor and Former Chair
 Department of Kinesiology and Health
 Georgia State University

About the Authors



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 time 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 the 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 an active member of SCAN, the Sports, Cardiovascular, and Wellness Nutritionists, a dietetic practice group of the American Dietetic Association, and a member of the American College of Sports Medicine. She is an avid recreational tennis player and a struggling student of French.



J. ANDREW DOYLE, Ph.D., FACSM, is an Associate Professor of Exercise Physiology and the Director of the Applied Physiology Laboratory in the Department of Kinesiology and Health at Georgia State University where he formerly served as the Department Chair. He received a B.S. in Zoology from Clemson University, an M.S. in Exercise Science from Georgia State University, and his doctorate in Exercise Physiology from the Ohio State University.

He has taught exercise physiology, exercise testing and fitness assessment, and exercise programming at the undergraduate and graduate level for over 20 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 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.

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

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