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Williams' NUTRITION

for Health, Fitness and Sport

Eric S. Rawson

J. David Branch

Tammy J. Stephenson

Thirteenth Edition

A photograph of two cyclists riding on a paved road. The cyclist in the foreground is wearing a white and black jersey and a white helmet. The cyclist behind is wearing a black and red jersey and a red helmet. They are riding on a road with a metal guardrail, with a large, rocky mountain in the background under a clear sky.

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WILLIAMS' NUTRITION

FOR HEALTH, FITNESS & SPORT

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Messiah University

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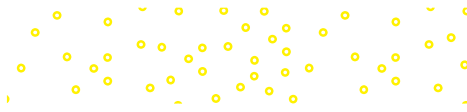
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WILLIAMS' NUTRITION FOR HEALTH, FITNESS AND SPORT

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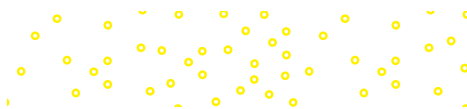
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Dedication



In memory of Melvin H. Williams

We dedicate this thirteenth 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, Catherine Bruce,
Anne Randolph, Tip, Brooks, Gracie,
Banks, and the rest of my family

—*J. David Branch*


To Brian, Bailey, Kylie Mae, and Ansley

—*Tammy J. Stephenson*

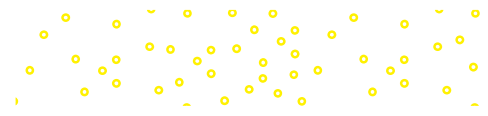
and

To our teachers, colleagues,
and students

Eric, David, and Tammy



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 University 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 180 professional presentations, is coeditor of the text *Nutrition for Elite Athletes*, coauthor of the 10th, 11th, and 12th editions of *Nutrition for Health, Fitness & Sport*, and has authored/coauthored 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, and his grandchildren.



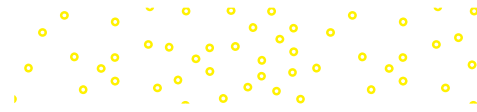


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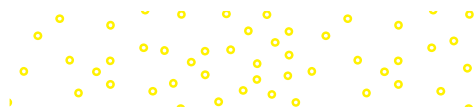
Tammy J. Stephenson, PhD, received her BS degree in Food Science and Human Nutrition, and PhD in Nutritional Sciences from the University of Kentucky. She has taught a variety of food, nutrition, and wellness courses, including sports nutrition and introductory nutrition, in the Department of Dietetics and Human Nutrition at the University of Kentucky for the past two decades. Currently, Dr. Stephenson serves as Department Chair, while continuing to teach both in person and online classes. Prior to assuming the Chair position, she served 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 and the Provost Office's Outstanding Teacher Award. 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 American College of Sports Medicine and the Sports and Human Performance Nutrition practice group of the Academy. Dr. Stephenson is coauthor of *Human Nutrition: Science for Healthy Living*, now in its third edition. Outside of the classroom, she enjoys yoga, cycling, hiking, reading, gardening, watching her daughters play sports, traveling, and spending time with her family.



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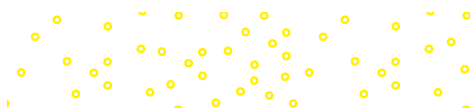
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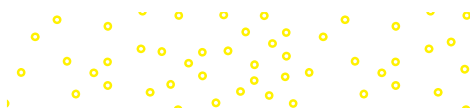
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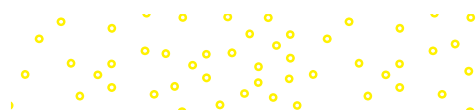
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Preface

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.

Textbook Overview

This book uses a question-answer approach, which is convenient when you may have occasional short periods to study, such as between classes. 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 exercise performance. Chapter 3 focuses on energy and energy pathways in the body, the key to all exercise and sports activities.

Chapters 4 through 9 explore 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. Content on disordered eating and eating disorders is covered in Chapter 10, including a new section on relative energy deficiency in sport (RED-S). Chapter 13 summarizes dietary supplements and ergogenic aids and potential impacts on health and exercise performance. The textbook has been updated with the most recent information available on these supplements, including preworkout supplements, creatine, and caffeine. 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 Thirteenth 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 40 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 *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 thirteenth edition of the textbook, the following updates have been made.

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

- Updated statistics on the leading causes of death in the United States with an expanded discussion of those related to diet and/or physical activity
- New and revised *Training Tables* on current and interesting topics such as *Healthy People 2030* objectives, examples of physical activity options at different intensities, and more
- Physical activity guidelines section updated with the 2018 *Physical Activity Guidelines for Americans* recommendations and specific examples
- New content on the physical activity habits of Americans with updated 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 *2020–2025 Dietary Guidelines for Americans*, including an expanded discussion of those guidelines
- New information on nutrition and health misinformation and recommendations for evaluating nutrition and health content shared online, through social media, and more
- An introduction to ergogenic aids and general advice about their use, with specific details embedded throughout subsequent chapters
- Updated guidelines on evaluating and understanding different types of research studies and making evidence-based recommendations
- 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

- Updates throughout the chapter to reflect the recommendations of the *2020–2025 Dietary Guidelines for Americans* and associated MyPlate resources
- 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, showing the relationship between RDAs, AIs, ULs, and others
- Significantly revised section on plant-based diets, including nutrient intake, health effects, and more
- Expanded discussion of dairy alternatives and recommendations for meeting MyPlate food group needs for those who do not consume dairy products
- Updated figures and photos showing food labels and associated Nutrition Facts panels
- Specific dietary advice based on the most currently available literature and recommendations from evidence-based sources
- Updated 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
- Application Exercise based on a case-study scenario
- Updated Critical Thinking Questions
- New and revised references

Chapter 3—Human Energy

- Improved terminology for energy expenditure assessment
- New data on ultraprocessed foods, energy intake, and absorption
- New data on standing desks and energy expenditure
- Introduction of Relative Energy Deficiency in Sport (RED-S)
- Updated images
- New and revised references

Chapter 4—Carbohydrates: The Main Energy Food

- Updated data on the health effects of low glycemic-index diets and on glycemic index values
- Updates on energy metabolism and adenosine triphosphate production from carbohydrate
- Updates on the effects of altitude on carbohydrate metabolism and energy production
- Updates on non-nutritive sweeteners and dietary fiber and the microbiome
- Updated images
- New and revised references

Chapter 5—Fat: An Important Energy Source during Exercise

- Updated food label for finding hidden fats in foods
- Updated websites related to dietary fats and health
- Updates on fat-related dietary supplements
- Updated data on ergogenic and health-related effects of omega-3 fatty acid supplements
- Updated data on ergogenic effects of ketone supplements
- Updated cardiovascular risk calculator
- New image of recommended changes using the DASH eating plan to help lower blood pressure and LDL
- New table on guidelines to manage blood cholesterol
- Updated section on dietary recommendations to improve serum lipids and reduce the risk of atherosclerotic cardiovascular disease
- Updated images
- New and revised references

Chapter 6—Protein: The Tissue Builder

- Updated section on muscle protein synthesis and exercise
- New section on plant-based vs. animal proteins
- Updates on presleep protein ingestion
- New section on protein-related supplements, including data on creatine monohydrate, beta-alanine, dietary nitrate/beetroot, taurine, gelatin/collagen, beta-hydroxy beta-methylbutyrate, inosine, colostrum, and glucosamine/chondroitin
- Updated section on amino acid supplements including, branched-chain amino acids, glycine, glutamine, tyrosine, arginine/citrulline, arginine/lysine/ornithine, and tryptophan
- Updated section on protein ingestion and health risks
- Updated images
- 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 updated 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
- Photos provide a visual representation of good food sources for each vitamin
- Figure 7.5 showing the role of folate and vitamin B12 in red blood cell formation
- Revised *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
- Updated 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 and the *2020–2025 Dietary Guidelines for Americans*
- Expanded overview of minerals with additional content on the difference between major, trace, and possibly essential minerals, including 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 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
- Table 8.5 differentiating factors that influence iron bioavailability and an expanded section on iron-deficiency anemia
- Application Exercise is provided for students to evaluate minerals with potential ergogenic benefits and to develop informational handouts on one of those minerals
- Updated Multiple Choice and Critical Thinking Questions
- New and revised references

Chapter 9—Water, Electrolytes, and Temperature Regulation

- Extensive updating of chapter content with 55 deleted references and 64 new references
- Extensive revision of Table 9.1 Sodium Content of Common Foods
- Addition of age-related recommended intakes of sodium, chloride, and potassium based on *2020–2025 Dietary Guidelines for Americans*
- Extensive revision of Table 9.4 Potassium content in some common foods in the major Food Groups.

- Updated Figure 9.5 Sources of heat gain and heat loss
- New Training Table – Calculation of Sweat Rate
- Updated information in Table 9.5 Fluid-replacement and high-carbohydrate* beverage comparison chart per 8-oz serving
- Updated Table 9.6 Fluid consumption (milliliters) at a given percent carbohydrate concentration to obtain desired grams of carbohydrate
- New Training Table – Calculation of hydration volume
- Addition of plant-based dairy alternatives in Table 9.12 The DASH eating plan (servings per day based on a 2,000-kcal diet)
- Critical Thinking Question
- New and revised references

Chapter 10—Body Weight and Composition for Health and Sport

- Chapter organization has been updated to enhance flow and readability of the chapter. This includes a re-organization of the section on “Disordered Eating and Eating Disorders” and including that at the end of the chapter, rather than embedded in the middle. Throughout the chapter, significant modifications have been made based on the most current science in the areas of body composition, obesity, and disordered eating and eating disorders.
- Given the rapidly evolving nature of the content covered in this chapter, we have made extensive updates to the references, including the most current science and evidence-based recommendations.
- Multiple tables and figures have been updated for clarity and to support student learning. This includes:
 - New Table 10.2 Body mass index percentile categories for children and adolescents ages 2-20
 - New Figure 10.2 Hydrostatic Weighing
 - Revised Table 10.3 Methods used to determine body composition using 2- and 3-component models
 - New Figure 10.3 Air-displacement plethysmography
 - New Figure 10.5 Bioelectrical impedance
 - New Figure 10.6 DEXA
 - Updated Table 10.10 Weight-loss drugs approved by the US Food and Drug Administration
 - Elimination of Training Table/Replacement with Table 10.11 Symptoms of anorexia nervosa
 - Elimination of Training Table/Replacement with Table 10.12 DSM-V criteria for bulimia nervosa
 - Elimination of Training Table/Replacement with Tables 10.13 Behaviors associate with binge eating disorders
 - Elimination of Training Table/Replacement with Tables 10.14 Other selected disordered eating and body image disorders
 - New Table 10.17 Body fat percentage ranges by sport and gender
- Extensive updates to the section of the chapter focusing on eating disorders. New content added contrasting disordered eating and eating disorders. Most current scientific evidence provided related to eating disorders as well as new content on risk factors for eating disorders and an overview of treatment options.

- Significant revisions to the section on the female athlete triad and new content added on the male athlete triad.
- The chapter has been updated to best support diversity, equity, inclusion, and accessibility (DEIA) as it relates to the field of body weight and body composition. This includes changes to language and terminology (e.g. individual with obesity replaces obese individual) as well as how content is presented.

Chapter 11—Weight Maintenance and Loss through Proper Nutrition and Exercise

- Chapter has been significantly revised and re-organized with new section headings and new topics introduced
- New figures and tables throughout the chapter displaying the most current data on overweight and obesity and evidence-based recommendations to support weight loss and maintenance
- Figure 11.2 shows the relationship between overweight and obesity and risk for several chronic health conditions
- Weight bias is introduced with new content on how health-care providers can minimize weight bias in their practice
- New content on ultra-processed foods and how intake impacts weight loss efforts
- Section dedicated to mindful eating practices, including Table 11.4 summarizing general characteristics of mindful eating
- Updates based on the most current evidence on the impact of physical activity on weight loss and maintaining that weight loss long-term
- Key recommendations of the American College of Sports Medicine, Academy of Nutrition and Dietetics and the *2018 Physical Activity Guidelines for Americans*
- Overview of factors to be considered when selecting a weight-loss program and summary of weight-loss program types
- Section dedicated to specific recommendations for weight loss in children and adolescents with overweight or obesity
- Table 11.11 summarizes the three main types of intermittent fasting and the chapter explores specific dietary patterns that may support weight loss, including high-protein diets, keto diets, and more
- New recommendations for exercise before and after bariatric surgery are provided
- Table 11.12 summarizes common symptoms of low energy availability in athletes
- All new end-of-chapter materials - application exercise, multiple-choice questions, and critical thinking questions.
- The reference list has been updated to include the most current research available

Chapter 12—Gaining Lean Body Mass through Proper Nutrition and Exercise

- Extensive updating of chapter content with 12 deleted references and 22 new references
- Case study of a diet and exercise plan for a 20 year old male college basketball guard to increase lean body mass for the next season.
- Updated Table 12.1 Estimated kilocalorie intake needed for a 170-pound, 76" tall, sedentary, 20-year-old low-active (Physical

Activity Coefficient=1.1) male basketball player to gain 1 pound per week.

- Updated Table 12.2. A sample high-kcal 24-hr meal plan diet with sufficient protein intake combined with progressive resistance training to support muscle synthesis.
- New Table 12.3 Volumes for eight resistance exercises, total volumes for separate upper-body and back/lower body sessions, and weekly volume.
- Table 12.4 Weekly record for resistance-training program of nine exercises
- New art and photographs for Figures 12.7, 12.8, 12.9, 12.10, 12.11, 12./12, 12.13, and 12.14
- Summary points of 2020 American Academy of Pediatrics (AAP) position statement regarding resistance training for children and adolescents.

Chapter 13—Nutritional Supplements and Ergogenic Aids

- Extensive updating of chapter content with 102 deleted references and 117 new references
- Edited Figure 13.2 Simplified pathways for alcohol metabolism
- Updated text summarizing use of alcohol as an ergogenic aid
- Added “driving while impaired” and “aggressive behavior” sub-headings under psychological effects of alcohol
- New heading entitled “Alcohol Consumption in College Students and Athletes”
- New text added on moderate alcohol consumption and kidney cancer
- Extensive revision of Table 13.6 Caffeine content in selected products
- Updated text summarizing use of caffeine as an ergogenic aid
- Updated Table 13.8 Caffeine content in selected energy drinks (n = 7) and shots (n = 5) with descriptive information on caffeine content for 220 energy drinks and 36 energy shots
- Added text on pre-workout supplements
- New Table 13.10. Summary of position stands from the American College of Sports Medicine (ACSM), the National Strength and Conditioning Association (NSCA), and the National Athletic Trainers’ Association (NATA) regarding use and abuse of Anabolic-Androgenic Steroids (AAS) and/or human Growth Hormone (hGH).
- Deleted discussion of nitrates

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 evaluating 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 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.

Acknowledgments

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 nutrition educators who reviewed this text.

*Eric S. Rawson
J. David Branch
Tammy J. Stephenson*

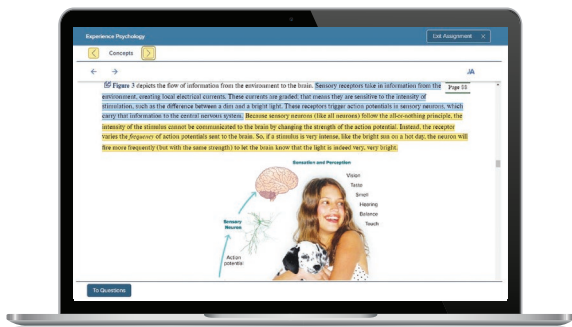
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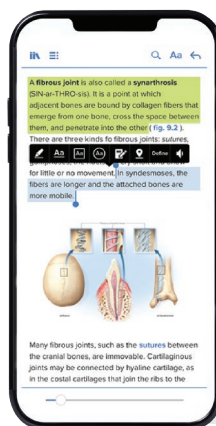
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NutritionCalc Plus is a powerful dietary analysis tool featuring over 106,000 foods from the ESHA Research nutrient database, which is comprised of data from the latest USDA Standard Reference database, manufacturer's data, restaurant data, and data from literature sources. NutritionCalc Plus allows users to track food and activities and then analyze their choices with a robust selection of intuitive reports. An updated mobile-friendly interface has been developed according to WCAG guidelines for further accessibility.

Auto-graded, case study-based assignments in Connect correspond with NutritionCalc Plus reports for students to apply their knowledge and gain further insight into dietary analysis.

Assess My Diet: Auto-graded personal dietary analysis in Connect.

One of the challenges many instructors face when teaching the nutrition course is having the time to grade individual dietary analysis projects. To help overcome this challenge, we've created auto-graded assignments in Connect that complement the NutritionCalc Plus tool. Students are directed to answer questions about their dietary patterns based on generated reports from NutritionCalc Plus. These assignments were created and reviewed by instructors just like you, who use them in their own teaching. Designed to be relevant, current, and interesting, you will find them easy to implement and use in your classroom.

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Introduction to Nutrition for Health, Fitness, and Sports Performance

K E Y T E R M S

antipromoters
cytokines
doping
epidemiological research
epigenetics
epigenome
ergogenic aids
exercise
experimental research
health-related fitness
high-intensity interval training (HIIT)
malnutrition
meta-analysis
nutrient



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CHAPTER ONE

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. Explain nutrition and health misinformation and provide strategies that can be utilized to determine whether claims regarding a dietary recommendation 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.

nutrition
nutrition and health misinformation
physical activity
physical fitness
promoters
Prudent Healthy Diet
risk factor
sarcopenia
Sedentary Death Syndrome (SeDS)
sports nutrition
sports-related fitness
sports supplements
structured physical activity
unstructured physical activity





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Introduction

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 2020

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 over one in five Americans. In 2020, COVID-19 was the third leading cause of death in the United States, accounting for over 10% of deaths. Of the leading causes of death, risk for heart disease, cancer, COVID-19, stroke, Alzheimer's disease, diabetes, and kidney disease have been linked to a person's

diet, physical activity habits, and/or body composition. 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.

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.

TABLE 1.1 Leading causes of death in the United States (2020)

	Approximate percentage of deaths
Heart disease*	20.6
Cancer*	17.8
COVID-19*	10.4
Unintentional injuries (accidents)	5.9
Stroke*	4.7
Chronic lower respiratory diseases	4.5
Alzheimer's disease*	4.0
Diabetes mellitus*	3.0
Influenza and pneumonia	1.6
Kidney disease*	1.6
All other causes	25.9

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

Source: U.S. Department of Health and Human Services, National Center for Health Statistics. *Mortality in the United States, 2020*. www.cdc.gov/nchs/data/databriefs/db427.pdf. Accessed September 24, 2022.



Sam Edwards/Getty Images

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 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 *exercisomics* 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 having obesity 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 2030* address issues specific to physical activity and diet choices. The *Training Table* in this section provides examples of such objectives.

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.

To be successful at high levels of competition, athletes must possess the appropriate biomechanical, physiological, psychological, and 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.



Training Table

Examples of some of the **Healthy People 2030** objectives related to physical activity:

- Reduce the proportion of adults who do no physical activity in their free time.
- Increase the proportion of adults who do enough aerobic physical activity for substantial health benefits.
- Increase the proportion of adults who walk or bike to get places.
- Increase the proportion of adolescents who do enough aerobic and muscle-strengthening activities.
- Increase the proportion of children and adolescents who play sports.

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

www.health.gov/healthypeople Check for the full report of *Healthy People 2030*.

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 composition, 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 2030* are increased levels of physical activity, a healthier diet, and reduced rates 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 <http://kahuna.clayton.edu/jqu/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.

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.



Nicholas Monu/Vetta/Getty Images

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.

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: Erik Isakson/Blend Images LLC; Cardiovascular: epicstockmedia/123RF; Body composition: ComStock/Stockbyte/Getty Images; Flexibility: Jupiterimages/Stockbyte/Getty Images

Muscular strength and endurance



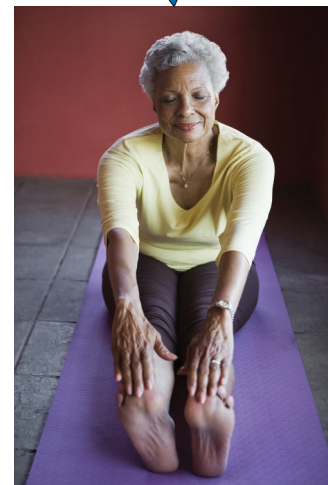
Cardiovascular-respiratory fitness



Health-Related Fitness



Body composition



Flexibility

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.

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.

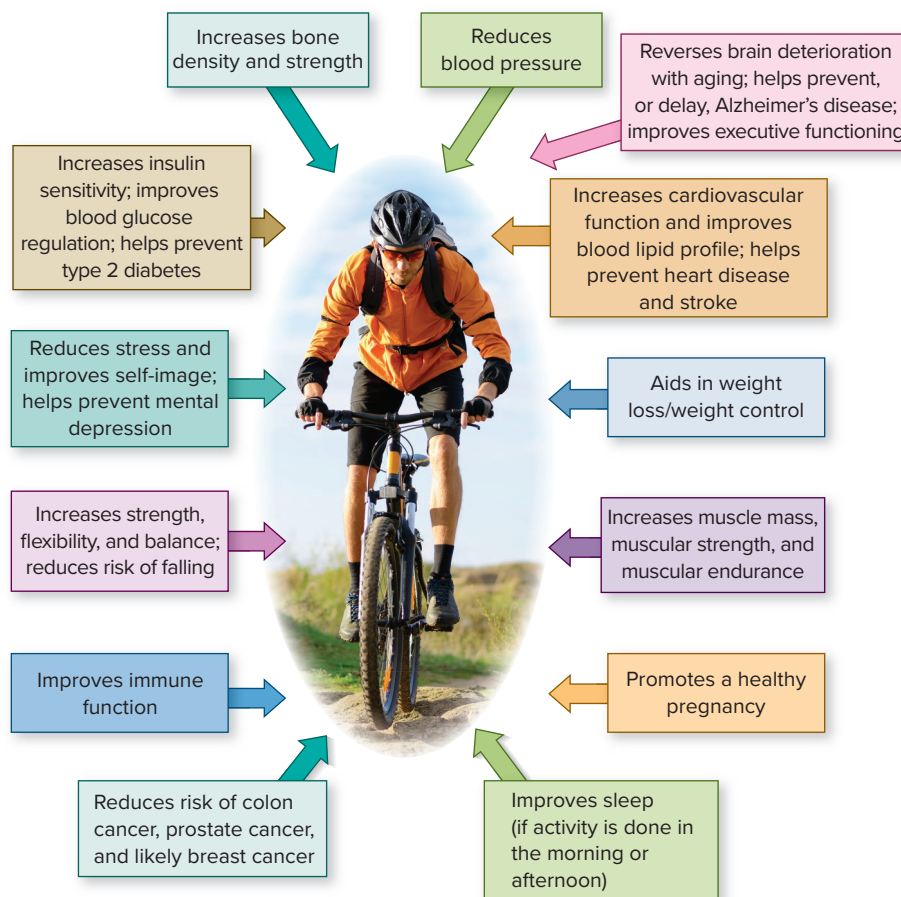
Principle of Reversibility Reversibility is also referred to as the principle of disuse, or the concept of *use it or lose it*. Without the use of exercise, the body will begin to lose the adaptations it has made over the course of the exercise program. Individuals who suffer a lapse in their exercise 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.

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



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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.

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.”

www.exerciseismedicine.org Website provides practical recommendations and guidance, including on physical activity during the COVID-19 pandemic.

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 Neuffer found that physical inactivity causes genes to misexpress proteins,

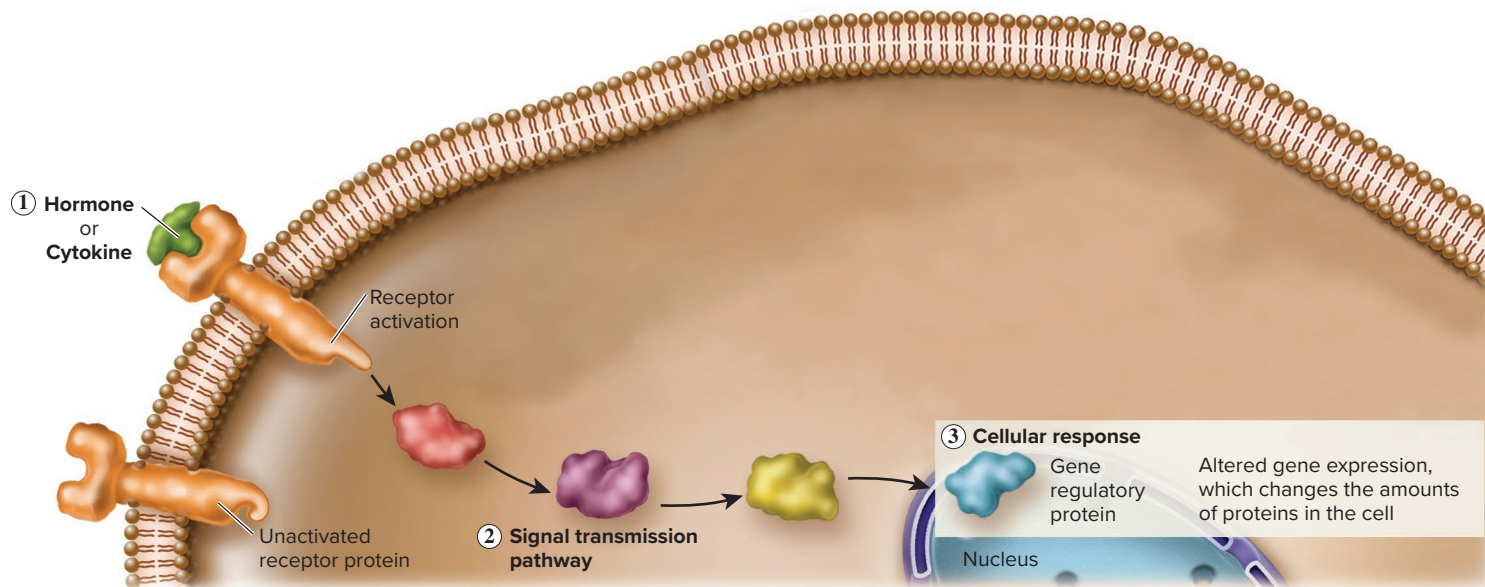


FIGURE 1.3 Exercise may induce adaptations that have favorable health effects in various body tissues. One suggested mechanism is the effect that various hormones or cytokines, which are produced during exercise, may have on gene regulation in body cells. (1) The hormone or cytokine binds to a cell receptor 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.

producing the metabolic dysfunctions that result 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.

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. Regular exercise is the only strategy that has been 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.

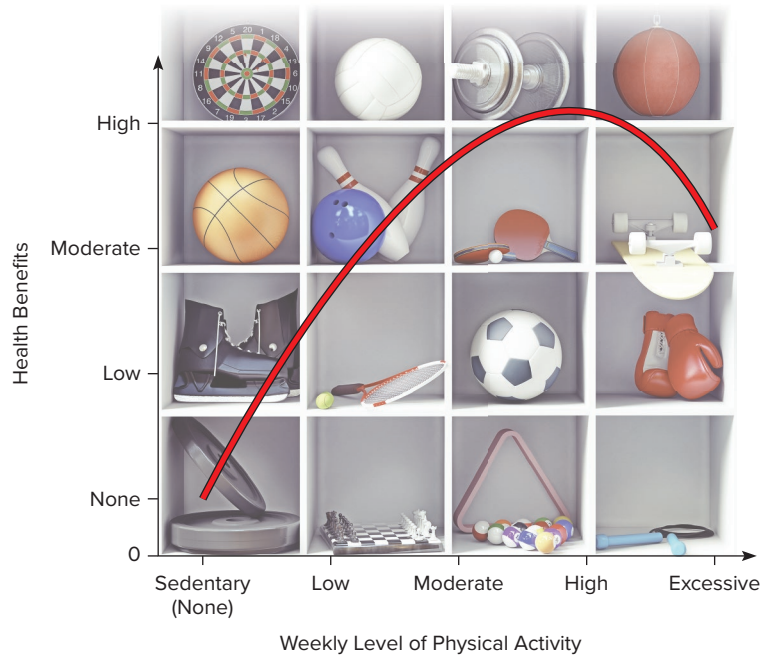
TABLE 1.2 Major cytokines produced in muscle and fat cells

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

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 obesity, heart disease, and diabetes, 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 *2018 Physical Activity Guidelines for Americans*. You can learn more about the process of developing the physical activity guidelines and follow the latest on these recommendations at <https://health.gov/paguidelines/>.



vict/iStock/Getty Images

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.

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 individuals who are sedentary will respond favorably to an aerobic exercise training program, such



Training Table

According to the *2018 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.

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 and body composition. Additionally, leisurely walking may be adequate physical activity for older adults 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 participate in 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.



Wavebreak Media Ltd/123RF

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 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 8–10 exercises that stress these major muscle groups. Individuals should perform about 8–12 repetitions of each exercise at least twice a week on nonconsecutive days. Older adults may lift lighter 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,