

**Sixth Edition**

# **Advanced Fitness Assessment and Exercise Prescription**



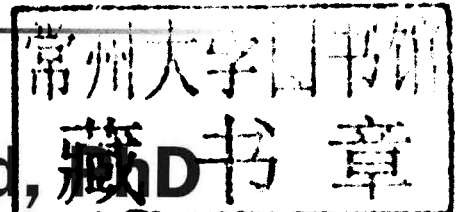
**Vivian H. Heyward**

*Sixth Edition*

# **Advanced Fitness Assessment and Exercise Prescription**

**Vivian H. Heyward,**

*University of New Mexico*



**Human Kinetics**

## Library of Congress Cataloging-in-Publication Data

Heyward, Vivian H.

Advanced fitness assessment and exercise prescription / Vivian H. Heyward. -- 6th ed.

p. ; cm.

Includes bibliographical references and index.

ISBN-13: 978-0-7360-8659-2 (hard cover)

ISBN-10: 0-7360-8659-5 (hard cover)

1. Physical fitness--Testing. 2. Exercise tests. 3. Health. I. Title.

[DNLM: 1. Physical Fitness--physiology. 2. Exercise Movement Techniques. 3. Exercise Test. QT 255 H622a 2010]

GV436.H48 2010

613.7--dc22

2009051573

ISBN-10: 0-7360-8659-5 (print)

ISBN-13: 978-0-7360-8659-2 (print)

Copyright © 2010, 2006, 2002, 1998, 1991 by Vivian H. Heyward

Copyright © 1984 by Burgess Publishing Company

All rights reserved. Except for use in a review, the reproduction or utilization of this work in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including xerography, photocopying, and recording, and in any information storage and retrieval system, is forbidden without the written permission of the publisher.

Notice: Permission to reproduce the following material is granted to instructors and agencies who have purchased *Advanced Fitness Assessment and Exercise Prescription, Sixth Edition*: pp. 318-321, 326-328, 330-332, 334, 335, 351-360, 363-371, 374-384, 390-408. The reproduction of other parts of this book is expressly forbidden by the above copyright notice. Persons or agencies who have not purchased *Advanced Fitness Assessment and Exercise Prescription, Sixth Edition*, may not reproduce any material.

The Web addresses cited in this text were current as of December, 2009, unless otherwise noted.

**Acquisitions Editors:** Michael S. Bahrke, PhD, Roger W. Earle, and Amy N. Tocco; **Developmental Editors:** Jillian Evans and Kevin Matz; **Assistant Editors:** Martha Gullo and Steven Calderwood; **Copyeditor:** Joyce Sexton; **Indexer:** Michael Ferreira; **Permission Manager:** Dalene Reeder; **Graphic Designer:** Joe Buck; **Graphic Artists:** Denise Lowry and Yvonne Griffith; **Cover Designer:** Keith Blomberg; **Photographer (interior):** Sarah Ritz, except where otherwise noted. Figures 8.1, 8.2, and 8.12a-b © Human Kinetics; **Photo Production Manager:** Jason Allen; **Art Manager:** Kelly Hendren; **Assistant Art Manager:** Alan L. Wilborn; **Illustrators:** Craig Newsom and Alan L. Wilborn; **Printer:** Thomson-Shore, Inc.

We thank the Exercise Physiology Laboratory at the University of New Mexico, Albuquerque, New Mexico, for assistance in providing the location for the photo shoot for this book.

Printed in the United States of America 10 9 8 7 6 5

The paper in this book is certified under a sustainable forestry program.

### Human Kinetics

Web site: [www.HumanKinetics.com](http://www.HumanKinetics.com)

United States: Human Kinetics, P.O. Box 5076, Champaign, IL 61825-5076

800-747-4457

email: [humank@hkusa.com](mailto:humank@hkusa.com)

Canada: Human Kinetics, 475 Devonshire Road Unit 100, Windsor, ON N8Y 2L5

800-465-7301 (in Canada only)

email: [info@hkcanada.com](mailto:info@hkcanada.com)

Europe: Human Kinetics, 107 Bradford Road, Stanningley, Leeds LS28 6 AT, United Kingdom

+44 (0) 113 255 5665

email: [hk@hkeurope.com](mailto:hk@hkeurope.com)

Australia: Human Kinetics, 57A Price Avenue, Lower Mitcham, South Australia 5062

08 8372 0999

e-mail: [info@hkaustralia.com](mailto:info@hkaustralia.com)

New Zealand: Human Kinetics, P.O. Box 80, Torrens Park, South Australia 5062

0800 222 062

e-mail: [info@hknewzealand.com](mailto:info@hknewzealand.com)

E4935

*In memory of Mom—  
for her gentle encouragement  
and unwavering confidence in me.*

# Preface

**A***dvanced Fitness Assessment and Exercise Prescription, Sixth Edition* is written primarily for exercise science students in advanced professional courses dealing with physical fitness appraisal and exercise prescription. This book is also a resource for exercise physiologists or personal trainers working in the public or private sector. Previous editions of this text have been adopted for course use by numerous universities and colleges and have been translated into Greek, Italian, Korean, Portuguese,

**eBook**  
available at  
HumanKinetics.com

and Spanish. Also, the sixth edition is now available as an electronic book, potentially allowing this book to reach a wider audience worldwide.

This book provides exercise scientists with the knowledge and skills needed to assess the physical fitness of apparently healthy individuals rather than individuals who have suspected or documented cardiovascular disease. Since this text is not clinically oriented, it provides limited information on the etiology and pathophysiology of chronic diseases, on clinical exercise testing, and on exercise prescriptions for clinical populations. Exercise scientists working with clinical populations are encouraged to consult clinically oriented books that provide detailed information for exercise testing and prescriptions for these populations.

In its well-balanced approach to the assessment of physical fitness, *Advanced Fitness Assessment and Exercise Prescription* addresses five components:

- Cardiorespiratory endurance
- Muscular fitness
- Body weight and composition
- Flexibility
- Balance

This text is unique in its scope and in the depth of its content, organization, and approach to the

subject matter. Introductory texts typically focus on field testing for evaluating physical fitness. Although this text includes some field tests, it emphasizes laboratory techniques for assessment. The scope and depth of information make this text an important resource for practitioners, especially those employed in health and fitness settings. Generally, the text is organized around physical fitness components, providing for each of them one chapter on assessment followed by one chapter on exercise prescription. The multidisciplinary approach of this text synthesizes concepts, principles, and theories based on research in exercise physiology, kinesiology, measurement, psychology, and nutrition. The result is a direct and clear-cut approach to physical fitness assessment and exercise prescription.

With the exception of the addition of a new chapter, “Assessing Balance and Designing Balance Programs,” the scope and organization of the sixth edition of *Advanced Fitness Assessment and Exercise Prescription* are not substantially different from previous editions. The new chapter contains information dealing with assessment of balance and the design of exercise programs for improving balance.

Pedagogical tools include Key Questions at the beginning of each chapter and Key Points, Review Questions, and Key Terms at the end of each chapter. Each of the key terms is defined in the glossary at the back of the book. These tools will help you identify the key terms and concepts and test your knowledge and understanding of the material in each chapter.

Pertinent information from the latest edition (2010) of ACSM’s *Guidelines for Exercise Testing and Prescription* is incorporated throughout the text. Updated phone numbers and Web sites for equipment manufacturers and suppliers are included. The following list highlights some of the changes in

chapters of *Advanced Fitness Assessment and Exercise Prescription*, Sixth Edition:

## Chapter 1

- Recent global and U.S. statistics on the prevalence of chronic diseases
- New research substantiating the link between physical activity and disease risk
- New physical activity recommendations from the U.S. government, the American Heart Association, and the American College of Sports Medicine (ACSM)
- Information about beneficial effects of physical activity on life expectancy

## Chapter 2

- Updated information on automated sphygmomanometers
- Updated resources for measurement and interpretation of the electrocardiogram

## Chapter 3

- Expanded information about psychological models related to behavior change
- Updated information about the certification and licensure of exercise professionals
- Comparison of selected professional certifications
- Use of technology to promote physical activity

## Chapter 4

- Latest (2010) ACSM guidelines for exercise testing
- New equations for predicting maximum heart rate
- Recumbent stepper maximal exercise test protocol
- Use of the OMNI pictorial scales for ratings of perceived exertion during exercise

## Chapter 5

- Latest (2010) ACSM guidelines for designing aerobic exercise programs
- Use of high-intensity interval training to improve  $\dot{V}O_{2\max}$

## Chapter 6

- Use of handheld dynamometers for assessing isometric strength of muscle groups
- Updated guidelines for testing muscular fitness of children and older adults

## Chapter 7

- Updated guidelines for developing resistance training programs for novice, intermediate, and advanced weightlifters
- Updated information on designing resistance training programs for children
- Use of whole-body vibration training to improve strength and reduce muscle soreness
- Use of stability balls and resistance bands to increase strength
- Updated information about functional training and core training
- Updated information about the effectiveness of supplements for increasing strength

## Chapter 8

- Updated information about air displacement plethysmography and dual-energy X-ray absorptiometry as reference methods for body composition assessment
- Use of bioimpedance spectroscopy to estimate body composition
- Newly developed skinfold prediction equation for athletes
- Updated information on using anthropometric indices to classify disease risk

## Chapter 9

- Updated statistics on the global prevalence of obesity in children and adults
- Use of high-intensity aerobic exercise for weight loss
- Updated information on weight loss diets, including OmniHeart diets
- Updated information on protein requirements for active individuals
- New guidelines from the ACSM and the American Dietetic Association for physical activity interventions for weight loss and weight gain

**Chapter 10**

- Updated information on ballistic stretching
- Validity of clinical tests for measuring hamstring flexibility

**Chapter 11**

- Updated guidelines for designing stretching programs
- Use of vibration training for improving flexibility
- Updated information about stretching and injury prevention
- New information from the North American Spine Society about exercises to prevent back pain

**Chapter 12**

- Factors affecting balance
- Guidelines for balance testing
- Field and laboratory tests for assessing balance
- Recommendations for designing balance training programs

**Appendixes**

- Updated Web sites for professional organizations
- OMNI pictorial scales for assessing ratings of perceived exertion of adults and children

These updates and additions provide a comprehensive approach to physical fitness appraisal and exercise prescription. I hope you will use *Advanced Fitness Assessment and Exercise Prescription, Sixth Edition*, to improve your knowledge, skill, and professional competence as an exercise scientist.

# Acknowledgments

---

I have been authoring and publishing *Advanced Fitness Assessment and Exercise Prescription* since 1984. The first edition was titled *Designs for Fitness* and was published by Burgess Publishing Co. It was a softcover book having about 200 pages. My colleague, Dr. Swede Schoeller, took the photos for that edition, and my secretary at the university, Eileen Fletcher, typed the manuscript on her Smith-Corona.

The second edition was published by Human Kinetics Publishers in 1991. This edition was a hardcover book consisting of 350 pages. For this edition, my dear friend, Linda K. Gilkey, took the photos, and for the first time the manuscript was typed using a DOS word processing system by my secretary, Sandi Travis.

In 1998, the third edition was published by HK. The book grew in size from a 7" x 9" format to an 8" x 11" format. Once again, Linda K. Gilkey took the photos, and the computer graphics were done by Dr. Robert Robergs, Dr. Brent Ruby, and Dr. Peter Egan.

The fourth edition, published by HK in 2002, was 370 pages. My colleagues, Dr. Christine Mermier,

Dr. Virginia Wilmerding, Dr. Len Kravitz, and Dr. Donna Lockner, shared their excellent ideas and expertise. My developmental editors, Elaine Mustain and Maggie Schwarzentraub, meticulously edited this edition.

In 2006, the fifth edition was released. For this edition, the total number of pages increased to 425, and HK updated all of the photos. Sarah Ritz did an excellent job organizing and taking these photos. My colleague, Dr. Dale Wagner, contributed the test question bank that accompanied this edition.

Finally, the sixth edition was released in May 2010. For the first time, this book was also published as an e-book. The book has expanded to 480 pages. Once again, I would like to acknowledge the contributions of my colleagues: Dr. Dale Wagner updated the test question bank, and Dr. Ann Gibson prepared the slides for the presentation package.

I am indebted to each individual who played a role in the metamorphosis and continued success of *Advanced Fitness Assessment and Exercise Prescription*.

# Contents

---

**Preface ix**

**Acknowledgments xiii**

|                  |  |           |
|------------------|--|-----------|
| <b>Chapter 1</b> | <b>Physical Activity, Health, and Chronic Disease</b>                              | <b>1</b>  |
|                  | Physical Activity, Health, and Disease: An Overview. . . . .                       | 1         |
|                  | Cardiovascular Disease . . . . .   | 8         |
|                  | Hypertension . . . . .   | 9         |
|                  | Hypercholesterolemia and Dyslipidemia . . . . .                                    | 11        |
|                  | Tobacco . . . . .  | 12        |
|                  | Diabetes Mellitus . . . . .  | 12        |
|                  | Obesity and Overweight . . . . .   | 13        |
|                  | Metabolic Syndrome . . . . .   | 14        |
|                  | Cancer . . . . .   | 15        |
|                  | Musculoskeletal Diseases and Disorders . . . . .                                   | 15        |
|                  | Aging . . . . .  | 16        |
|                  | Review Material. . . . .   | 17        |
| <br>             |  |           |
| <b>Chapter 2</b> | <b>Preliminary Health Screening and Risk Classification</b>                        | <b>19</b> |
|                  | Preliminary Health Evaluation . . . . .  | 19        |
|                  | Testing Procedures for Blood Pressure, Heart Rate, and Electrocardiogram . . . . . | 27        |
|                  | Review Material. . . . .   | 37        |
| <br>             |  |           |
| <b>Chapter 3</b> | <b>Principles of Assessment, Prescription, and Exercise Program Adherence</b>      | <b>39</b> |
|                  | Physical Fitness Testing. . . . .  | 40        |
|                  | Basic Principles for Exercise Program Design . . . . .                             | 47        |
|                  | Exercise Program Adherence . . . . .   | 50        |
|                  | Using Technology to Promote Physical Activity . . . . .                            | 54        |
|                  | Exercise Science as a Profession . . . . .   | 57        |
|                  | Review Material. . . . .   | 62        |
| <br>             |  |           |
| <b>Chapter 4</b> | <b>Assessing Cardiorespiratory Fitness</b>   | <b>65</b> |
|                  | Definition of Terms . . . . .  | 65        |
|                  | Graded Exercise Testing: Guidelines and Procedures . . . . .                       | 66        |
|                  | Maximal Exercise Test Protocols. . . . .   | 70        |
|                  | Submaximal Exercise Test Protocols. . . . .  | 84        |

|  |     |
|--|-----|
| Field Tests for Assessing Aerobic Fitness . . . . .      | 92  |
| Exercise Testing for Children and Older Adults . . . . . | 95  |
| Review Material. . . . .                                 | 100 |

## **Chapter 5      Designing Cardiorespiratory Exercise Programs      103**

|  |     |
|--|-----|
| The Exercise Prescription . . . . .          | 103 |
| Aerobic Training Methods and Modes . . . . . | 115 |
| Personalized Exercise Programs . . . . .     | 119 |
| Review Material. . . . .                     | 127 |

## **Chapter 6      Assessing Muscular Fitness      129**

|   |     |
|---|-----|
| Definition of Terms . . . . .                                     | 129 |
| Strength and Muscular Endurance Assessment . . . . .              | 130 |
| Sources of Measurement Error in Muscular Fitness Testing. . . . . | 142 |
| Additional Considerations for Muscular Fitness Testing. . . . .   | 143 |
| Muscular Fitness Testing of Older Adults. . . . .                 | 146 |
| Muscular Fitness Testing of Children. . . . .                     | 150 |
| Review Material. . . . .  | 152 |

## **Chapter 7      Designing Resistance Training Programs      155**

|   |     |
|---|-----|
| Types of Resistance Training . . . . .              | 155 |
| Developing Resistance Training Programs . . . . .   | 166 |
| Common Questions About Resistance Training. . . . . | 173 |
| Effects of Resistance Training Programs . . . . .   | 178 |
| Muscular Soreness . . . . .                         | 183 |
| Review Material. . . . .                            | 185 |

## **Chapter 8      Assessing Body Composition      189**

|  |     |
|--|-----|
| Classification and Uses of Body Composition Measures . . . . . | 190 |
| Body Composition Models. . . . .                               | 190 |
| Reference Methods for Assessing Body Composition. . . . .      | 191 |
| Field Methods for Assessing Body Composition . . . . .         | 202 |
| Review Material. . . . .                                       | 229 |

## **Chapter 9      Designing Weight Management and Body Composition Programs      231**

|  |     |
|--|-----|
| Obesity, Overweight, and Underweight: Definitions and Trends . . . . . | 231 |
| Obesity: Types and Causes . . . . .                                    | 234 |
| Weight Management Principles and Practices . . . . .                   | 237 |
| Well-Balanced Nutrition . . . . .                                      | 238 |
| Designing Weight Management Programs: Preliminary Steps . . . . .      | 244 |

|  |     |
|--|-----|
| Designing Weight Loss Programs . . . . .                 | 250 |
| Designing Weight Gain Programs . . . . .                 | 260 |
| Designing Programs to Improve Body Composition . . . . . | 261 |
| Review Material. . . . .                                 | 263 |

## **Chapter 10    Assessing Flexibility    265**

|  |     |
|--|-----|
| Basics of Flexibility . . . . .              | 265 |
| Assessment of Flexibility . . . . .          | 267 |
| Flexibility Testing of Older Adults. . . . . | 278 |
| Review Material. . . . .                     | 282 |

## **Chapter 11    Designing Programs for Flexibility and Low Back Care    283**

|   |     |
|---|-----|
| Training Principles. . . . .                                    | 283 |
| Stretching Methods . . . . .                                    | 284 |
| Designing Flexibility Programs: Exercise Prescription . . . . . | 288 |
| Designing Low Back Care Exercise Programs. . . . .              | 291 |
| Review Material. . . . .  | 295 |

## **Chapter 12    Assessing Balance and Designing Balance Programs    297**

|  |     |
|--|-----|
| Definitions and Nature of Balance . . . . .            | 297 |
| Factors Affecting Balance and Risk of Falling. . . . . | 298 |
| Assessment of Balance . . . . .                        | 299 |
| Designing Balance Training Programs . . . . .          | 307 |
| Review Material. . . . .                               | 313 |

## **Appendix A    Health and Fitness Appraisal    315**

|   |     |
|---|-----|
| A.1    Physical Activity Readiness Questionnaire (PAR-Q) . . . . .                | 316 |
| A.2    Medical History Questionnaire . . . . .                                    | 318 |
| A.3    Checklist for Signs and Symptoms of Disease . . . . .                      | 320 |
| A.4    Physical Activity Readiness Medical Examination (PARmed-X) . . . . .       | 322 |
| A.5    Lifestyle Evaluation . . . . .   | 326 |
| A.6    Informed Consent . . . . .   | 330 |
| A.7    Web Sites for Selected Professional Organizations and Institutes . . . . . | 332 |

## **Appendix B    Cardiorespiratory Assessments    333**

|  |     |
|--|-----|
| B.1    Summary of Graded Exercise Test and Cardiorespiratory<br>Field Test Protocols . . . . . | 334 |
| B.2    Rockport Fitness Charts. . . . .  | 336 |
| B.3    Step Test Protocols . . . . .   | 338 |
| B.4    OMNI Ratings of Perceived Exertion Scales. . . . .                                      | 341 |
| B.5    Analysis of Sample Case Study in Chapter 5 . . . . .                                    | 344 |

|                              |   |            |
|------------------------------|---|------------|
| <b>Appendix C</b>            | <b>Muscular Fitness Exercises and Norms</b>   | <b>347</b> |
| C.1                          | Standardized Testing Protocols for Digital, Handheld Dynamometry . . .                                | 348        |
| C.2                          | Average Strength, Endurance, and Power Values<br>for Isokinetic (Omni-Tron) Tests . . . . .           | 349        |
| C.3                          | Isometric Exercises . . . . .   | 351        |
| C.4                          | Dynamic Resistance Training Exercises . . . . .   | 355        |
| <b>Appendix D</b>            | <b>Body Composition Assessments</b>   | <b>361</b> |
| D.1                          | Prediction Equations for Residual Volume . . . . .  | 362        |
| D.2                          | Standardized Sites for Skinfold Measurements . . . . .  | 363        |
| D.3                          | Skinfold Sites for Jackson's Generalized Skinfold Equations. . . . .                                  | 368        |
| D.4                          | Standardized Sites for Circumference Measurements. . . . .  | 369        |
| D.5                          | Standardized Sites for Bony Breadth Measurements . . . . .  | 370        |
| D.6                          | Ashwell Body Shape Chart. . . . .   | 371        |
| <b>Appendix E</b>            | <b>Energy Intake and Expenditure</b>  | <b>373</b> |
| E.1                          | Food Record and RDA Profile . . . . .   | 374        |
| E.2                          | Sample Computerized Analysis of Food Intake . . . . .   | 376        |
| E.3                          | Physical Activity Log . . . . .   | 381        |
| E.4                          | Gross Energy Expenditure for Conditioning Exercises, Sports,<br>and Recreational Activities . . . . . | 382        |
| E.5                          | Healthy Eating Pyramids. . . . .  | 385        |
| <b>Appendix F</b>            | <b>Flexibility and Low Back Care Exercises</b>  | <b>389</b> |
| F.1                          | Selected Flexibility Exercises . . . . .  | 390        |
| F.2                          | Exercise Do's and Don'ts . . . . .  | 399        |
| F.3                          | Exercises for Low Back Care. . . . .  | 404        |
| <b>List of Abbreviations</b> |   | <b>409</b> |
| <b>Glossary</b>              |   | <b>411</b> |
| <b>References</b>            |   | <b>423</b> |
| <b>Index</b>                 |   | <b>457</b> |
| <b>About the Author</b>      |   | <b>465</b> |

# Physical Activity, Health, and Chronic Disease

## KEY QUESTIONS

- Are adults in the United States getting enough physical activity?
- What diseases are associated with a sedentary lifestyle, and what are the major risk factors for these diseases?
- What are the benefits of regular physical activity in terms of disease prevention, and how does physical activity improve health?
- How much physical activity is needed for improved health benefits?
- What kinds of physical activities are suitable for typical people, and how often should they exercise?

Although physical activity plays an important role in the prevention of chronic diseases, an alarming percentage of adults in the United States report no physical activity during leisure time. One of the national health objectives for the year 2010 is to increase to 30% the proportion of people aged 18 yr and older who regularly (preferably daily) engage in moderate physical activity at least 30 min per day (U.S. Department of Health and Human Services 2000a). According to a U.S. national survey from the Centers for Disease Control and Prevention (CDC 2005), less than half (49.1%) of the adults met this physical activity recommendation. Approximately 24% of the American population report no leisure-time physical activity. Generally, women (47.9%) are

less likely to meet this recommendation than men (50.7%), and older ( $\geq 65$  yr) adults are less likely (39.0%) to meet it than younger (18-24 yr) adults (59.6%) (American Heart Association 2008g).

Physical inactivity is not just a problem in the United States; it is a global issue. According to the World Health Organization (2002b), ~60% of the global population did not meet the daily minimum recommendation of 30 min of moderate-intensity physical activity. In 2003, only 37% of men and 25% of women in the United Kingdom met the government's physical activity guidelines (British Heart Foundation 2006). Also, the Canadian Fitness and Lifestyle Research Institute reported that 67% of Canadians (25-55 yr) were physically inactive (Public Health Agency of Canada 2009). Thus, as an exercise specialist, you face the challenge of educating and motivating your clients to incorporate physical activity as a regular part of their lifestyles.

This chapter deals with physical activity trends, risk factors associated with chronic diseases, the role of regular physical activity in disease prevention and health, and physical activity guidelines and recommendations for improved health. For definitions of terminology used in this chapter, see the glossary on page 411.

## PHYSICAL ACTIVITY, HEALTH, AND DISEASE: AN OVERVIEW

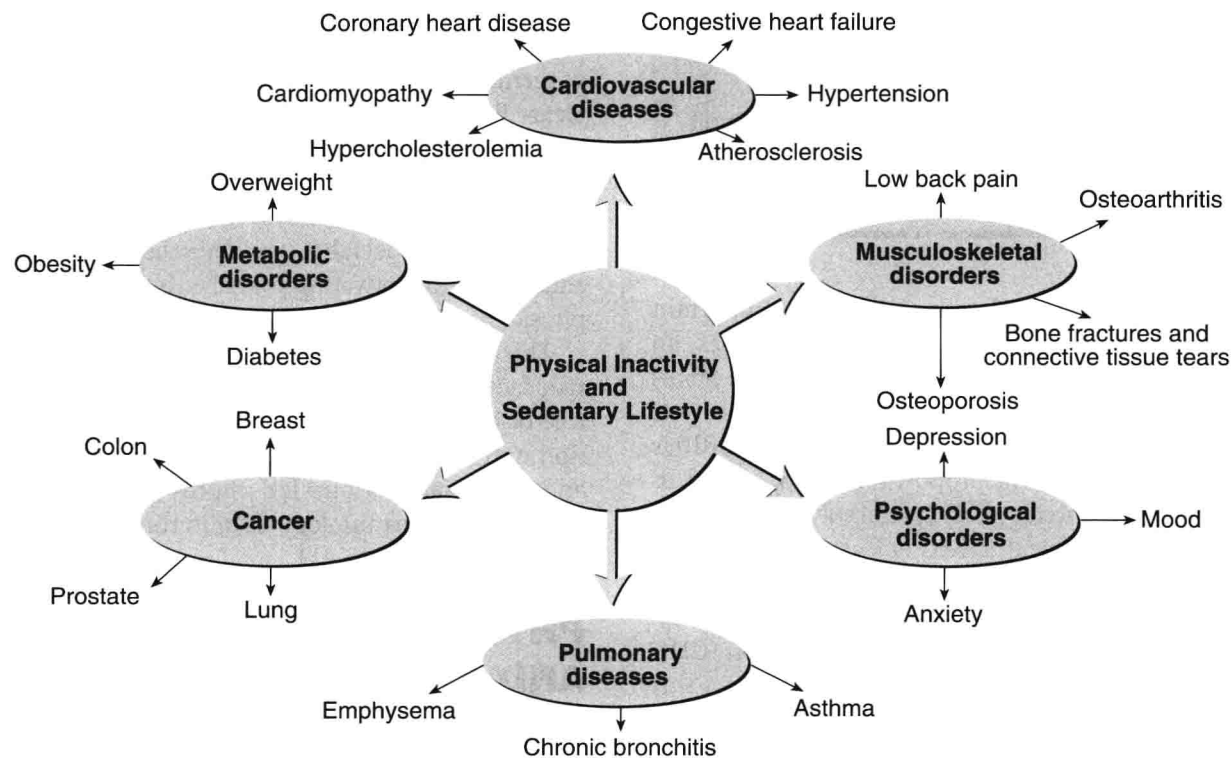
Our increased reliance on technology has substantially lessened work-related physical activity, as well

as the energy expenditure required for activities of daily living like cleaning the house, washing clothes and dishes, mowing the lawn, and traveling to work. What would have once required an hour of physical work now can be accomplished in just a few seconds by pushing a button or setting a dial. As a result, more time is available to pursue leisure activities. The unfortunate fact is, however, that many individuals do not engage in physical activity during their leisure time.

Although the human body is designed for movement and strenuous physical activity, exercise is not a part of the average lifestyle. One cannot expect the human body to function optimally and to remain healthy for extended periods if the body is abused or is not used as intended. Physical inactivity has led to a rise in chronic diseases. Some experts believe that physical inactivity is the most important public health problem in the 21st century (Blair 2009). Each year at least 1.9 million people die as a result of physical inactivity (Cavill, Kahlmeier, and Racioppi 2006). Data from the Aerobics Center Longitudinal Study (Blair 2009) indicated that low cardiorespiratory fitness accounts for substantially more deaths (16%) compared to other risk factors (i.e., obesity

2-3%; smoking 8-10%; high cholesterol 2-4%; diabetes 2-4%; and hypertension 8-16%). Individuals who do not exercise regularly are at greater risk than others of developing chronic diseases such as coronary heart disease, hypertension, hypercholesterolemia, cancer, obesity, and musculoskeletal disorders (see figure 1.1).

For years, exercise scientists and health and fitness professionals have maintained that regular physical activity is the best defense against the development of many diseases, disorders, and illnesses. The importance of regular physical activity in preventing disease and premature death and in maintaining a high quality of life received recognition in the first U.S. surgeon general's report on physical activity and health, in which physical activity was identified as a national health objective (U.S. Department of Health and Human Services 1996). This report identified physical inactivity as a serious nationwide health problem, provided clear-cut scientific evidence linking physical activity to numerous health benefits, presented demographic data describing physical activity patterns and trends in the U.S. population, and made physical activity recommendations for improved health. In 1995 the



**Figure 1.1** Role of physical activity and exercise in disease prevention and rehabilitation.

CDC and the American College of Sports Medicine (ACSM) recommended that every U.S. adult should accumulate 30 min or more of moderate-intensity physical activity on most, preferably all, days of the week (Pate et al. 1995).

Since 1995, new scientific evidence has increased our understanding of the benefits of physical activity for improved health and quality of life. In light of these findings, the ACSM and American Heart Association (AHA) updated physical activity recommendations for healthy adults and older adults (Haskell et al. 2007; Nelson et al. 2007). These recommendations address how much and what kind of physical activity are needed to promote health and reduce the risk of chronic disease in adults. Table 1.1 summarizes the ACSM and AHA physical activity recommendations for adults. The recommended amounts of physical activity are in addition to routine activities of daily living (ADL) such as cooking, shopping, and walking around the home or from the parking lot. The intensity of exercise is expressed in **metabolic equivalents (METs)**. A MET is the ratio of the person's working (exercising) metabolic rate to the resting metabolic rate. One MET is defined as the energy cost of sitting

quietly. Moderate-intensity aerobic activity (3.0 to 6.0 METs or 5 to 6 on a 10-point perceived exertion scale) is operationally defined as activity that noticeably increases heart rate and lasts more than 10 min (e.g., brisk walking for 10 min). Vigorous-intensity activity (>6.0 METs or 7 to 8 on a 10-point perceived exertion scale) causes rapid breathing and increases heart rate substantially (e.g., jogging). For adults (18-64 yr) and older adults (≥65 yr), the ACSM and AHA recommend a minimum of 30 min of moderate-intensity aerobic activity 5 days per week, or 20 min of vigorous-intensity aerobic exercise 3 days per week. They also recommend moderate- to high-intensity (8- to 12-repetition maximum [RM] for adults and 10- to 15-RM for older adults) resistance training for a minimum of 2 nonconsecutive days per week. Balance and flexibility exercises are also suggested for older adults.

The U.S. Department of Health and Human Services released the 2008 "Physical Activity Guidelines for Americans" (Howley 2008). Table 1.2 summarizes these guidelines for children and adolescents (6-17 yr), adults (18-64 yr), and older adults (≥65 yr). The key message in these guidelines is that for substantial health benefits, adults should

**Table 1.1 ACSM and AHA Physical Activity Recommendations**

| Population group        | AEROBIC ACTIVITY <sup>a</sup>   |                                |                     | MUSCLE-STRENGTHENING ACTIVITY |  |                        | FLEXIBILITY OR BALANCE ACTIVITY  |
|-------------------------|---------------------------------|--------------------------------|---------------------|-------------------------------|--|------------------------|--|
|                         | Duration <sup>b</sup> (min/day) | Intensity                      | Frequency (days/wk) | Sets                          | Intensity and no. exercises                      | Frequency (days/wk)    |  |
| Healthy adults 18-64 yr | 30                              | Moderate (3.0-6.0 METs)        | Minimum 5           | 1                             | 8-12 RM; 8-10 exercises for major muscle groups  | ≥2 nonconsecutive days | No specific recommendation   |
|                         | 20                              | Vigorous (>6.0 METs)           | Minimum 3           |                               |  |                        |  |
| Older adults ≥65 yr     | 30                              | Moderate (5-6 on 10-pt. scale) | Minimum 5           | 1                             | 10-15 RM; 8-10 exercises for major muscle groups | 2 nonconsecutive days  | For flexibility at least 2 days/wk for at least 10 min each day, including balance exercises for those at risk for falls |
|                         | 20                              | Vigorous (7-8 on 10-pt. scale) | Minimum 3           |                               |  |                        |  |

<sup>a</sup>Combinations of moderate and vigorous intensity may be performed to meet recommendation (e.g., jogging 20 min on 2 days and brisk walking on 2 other days).

<sup>b</sup>Multiple bouts of moderate-intensity activity, each lasting more than 10 min, can be accumulated to meet the minimum duration of 30 min.

Table 1.2 2008 Physical Activity Guidelines for Americans

| Population group                 | AEROBIC ACTIVITIES                                      |   |                        |      | MUSCLE-STRENGTHENING ACTIVITIES                  |                                   |  | BONE-STRENGTHENING ACTIVITIES | FLEXIBILITY AND BALANCE ACTIVITIES  |
|----------------------------------|---|---|------------------------|------|--|-----------------------------------|--|-------------------------------|---|
|                                  | Duration  | Intensity <sup>a</sup>  | Frequency              | Sets | Intensity <sup>a</sup>                           | Frequency                         |  |                               |   |
| Children and adolescents 6-17 yr | ≥60 min   | Moderate and<br><br>Vigorous  | Daily<br><br>3 days/wk |      |  | Moderate to high<br><br>3 days/wk |  | 3 days/wk                     |   |
| Adults 18-64 yr                  |   |   |                        |      |  |                                   |  |                               |   |
| Inactive                         | 60-150 min/wk   | Light (1.1-2.9 METs) to moderate (3.0-5.9 METs)                               |                        | 1    | Light to moderate                                | 1 day/wk                          |  |                               | All adults should stretch to maintain flexibility for regular physical activity (PA) and activities of daily living (ADL) |
| Active                           | 150-300 min/wk<br>or                                    | Moderate (3.0-5.9 METs)<br>or   |                        | ≥1   | Moderate to high 8-12 RM                         | ≥2 days/wk                        |  |                               |   |
| Highly active                    | 75-150 min/wk<br>or<br>>300 min/wk<br>or<br>>150 min/wk | Vigorous (≥6.0 METs)<br>Moderate (3.0-5.9 METs)<br>or<br>Vigorous (≥6.0 METs) |                        | 2-3  | Moderate to high                                 | ≥2 days/wk                        |  |                               |   |
| Older adults ≥65 yr              |   |   |                        |      |  |                                   |  |                               |   |
| Inactive                         | 150 min/wk  | Light (RPE = 3-4) to moderate (RPE = 5-6)                                     | 5 days/wk              | 1    | Light (RPE = 3-4) to moderate (RPE = 5-6)        | 2-3 days/wk                       |  |                               | Older adults should stretch to maintain flexibility for regular PA and ADL.   |
| Active                           | 150-300 min/wk<br>or<br>75-150 min/wk                   | Moderate (RPE = 5-6)<br>or<br>Vigorous (RPE = 7-8)                            | ≥3 days/wk             | ≥1   | Moderate (RPE = 5-6) to high (RPE = 7-8) 8-12 RM | ≥2 days/wk, nonconsecutive days   |  |                               | ≥3 days/wk balance  |

<sup>a</sup>Intensity is expressed in METs and repetition maximums (RM) for adults; for older adults, intensity is expressed as a rating of perceived exertion (0-10 scale) and RM.

engage in aerobic exercise at least 150 min per week at a moderate intensity or 75 min per week at a vigorous intensity. In addition, adults and older adults should do muscle-strengthening activities at least 2 days per week. Children should do at least 60 min of physical activity every day. Most of the 60 min per day should be either moderate or vigorous aerobic activity and should include vigorous aerobic activities at least 3 days per week. Part of the 60 min or more of daily physical activity should be muscle-strengthening activities (at least 3 days a week) and bone-strengthening activities (at least 3 days a week).

Exercising 150 min/wk equates to expending approximately 1000 kcal·wk<sup>-1</sup>. Participating in moderate-intensity physical activity on a daily basis reduces the risk of coronary heart disease by 50% and the risk of hypertension, diabetes, and colon cancer by 30% (U.S. Department of Health and Human Services 1996). Also, the risk of breast cancer decreases by 18% in women who walk briskly 1.25 to 2.5 hr/wk (McTiernan et al. 2003).

“Canada’s Physical Activity Guide to Healthy Active Living” (Health Canada 2003) recommends accumulating 60 min of daily physical activity to stay healthy and participating in aerobic activities (4-7 days/wk), strength activities (2-4 days/wk), and flexibility activities (4-7 days/wk) to improve health. The duration of the activity depends on the intensity or effort: Perform light activities (e.g., walking or gardening) for 60 min, moderate activities (e.g., brisk walking or swimming) for 30 to 60 min, and vigorous activities (e.g., jogging or hockey) for 20 to 30 min.

Improvements in health benefits depend on the volume (i.e., combination of frequency, intensity, and duration) of physical activity. This is known as the **dose–response relationship** (Bouchard 2001; Canadian Society of Exercise Physiology 2003; Kesaniemi et al. 2001). Because of the dose–response relationship between physical activity and health, the ACSM and AHA physical activity recommendation states that “persons who wish to improve their personal fitness, reduce their risk for chronic diseases and disabilities, or prevent unhealthy weight gain will likely benefit by exceeding the minimum recommended amount of physical activity” (Haskell et al. 2007, p. 1431).

Figure 1.2 illustrates the general dose–response relationship between the volume of physical activity

## Health Benefits of Physical Activity

### Lower risk of

- premature death;
- coronary artery disease;
- stroke;
- type 2 diabetes and metabolic syndrome;
- high blood pressure;
- adverse blood lipid profile;
- colon, breast, lung, and endometrial cancers; and
- hip fractures.

### Reduction of

- abdominal obesity and
- feelings of depression and anxiety.

### Helps in

- weight loss, weight maintenance, and prevention of weight gain;
- prevention of falls and better functional health for older adults;
- improved cognitive function for older adults;
- increased bone density; and
- improved quality of sleep.

Data from U.S. Department of Health and Human Services, 2008, *Physical Activity Guidelines for Americans* (Washington, DC).

participation and selected health benefits that do not require a minimal threshold intensity for improvement like muscular strength and aerobic fitness. The volume of physical activity participation needed for the same degree of relative improvement (%) varies among health benefit indicators. For example, to improve triglycerides from 0% to 40% requires 250 kcal·wk<sup>-1</sup> of physical activity compared to 1800 kcal·wk<sup>-1</sup> for the same relative improvement (0% to 40%) in high-density lipoprotein (see figure 1.2). Additionally, you should note that too much physical activity, defined as engaging in 5 hr of structured high-intensity activity per week, may be associated with negative health consequences or overuse injuries. For extensive reviews of literature dealing with the dose–response relationship between physical activity and health, see *Medicine & Science in Sports & Exercise* (June 2001, Supplement).