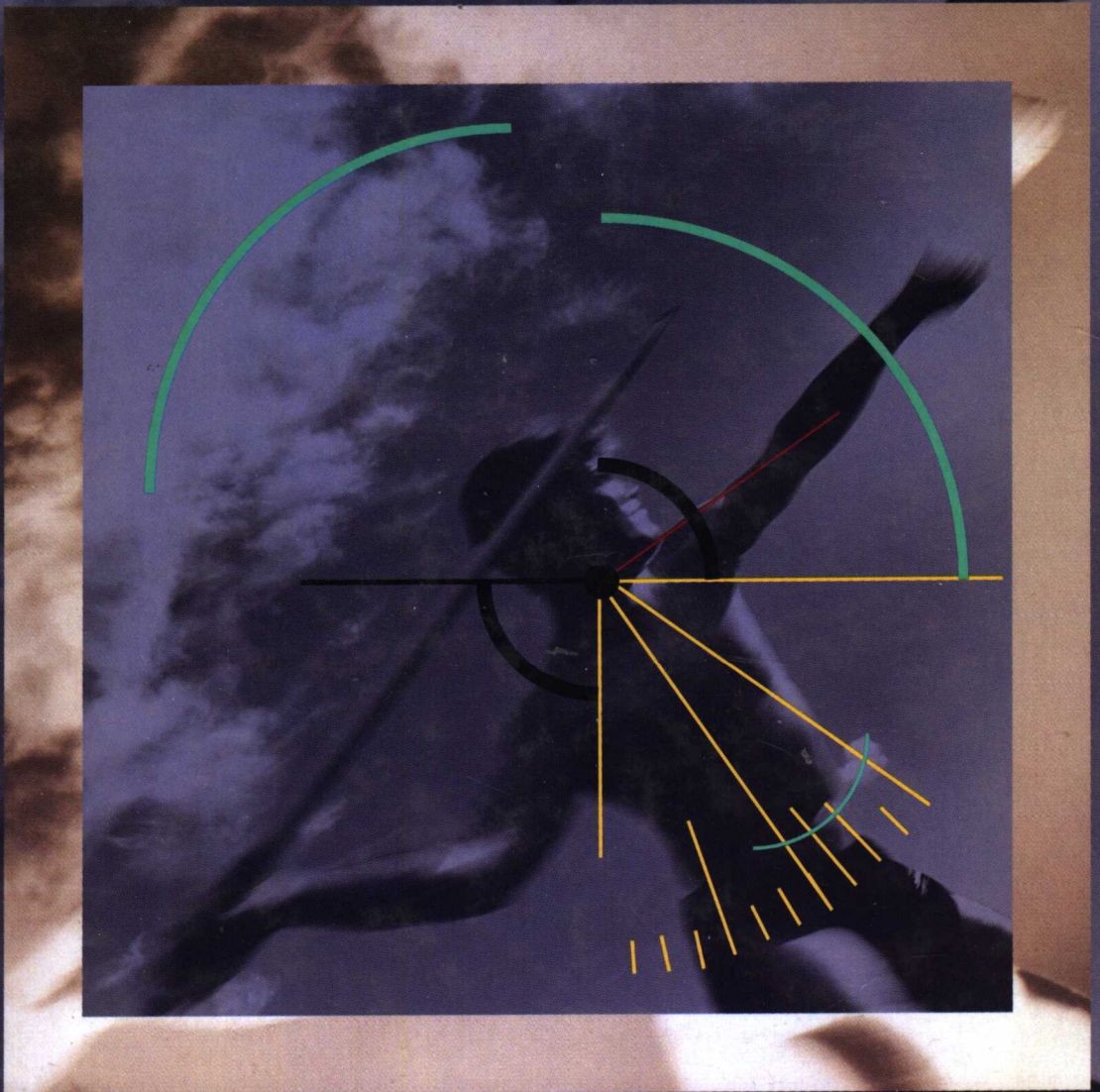


SECOND EDITION

# EXERCISE PHYSIOLOGY

Theory and Application to  
Fitness and Performance



SCOTT K. POWERS

EDWARD T. HOWLEY

SECOND EDITION

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Theory and Application to Fitness  
and Performance

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**T**his book is intended for exercise scientists, kinesiologists, physical educators, coaches, physical therapists, or specialists interested in adult fitness or cardiopulmonary rehabilitation. The general aim of this text is to provide the student with an up-to-date foundation for understanding the physiology of exercise. In addition, the book contains extensive practical applications, including work tests to evaluate cardiorespiratory fitness and information on training for improvement in physical fitness/health or performance.

This volume is intended for use in a one-semester upper-level undergraduate or beginning graduate exercise physiology course. Clearly, the text contains more material that can be covered during a typical fifteen-week semester. This is by design. The book was written to be comprehensive and afford instructors a large degree of freedom to select that material that they consider most important for the makeup of their class.

Among the exercise physiology texts currently available, many have major shortcomings. For example, some are too abbreviated and poorly illustrated, while others are too detailed or too advanced for students without a strong science background. We have attempted to write a textbook that is well illustrated and contains current information with sufficient detail for the student of exercise physiology who lacks a strong chemistry or biology background. Features that make this book unique are briefly described in the following sections.

## **Contents and Organization**

All topics in exercise physiology addressed within the second edition of this text are presented in a contemporary fashion with up-to-date references provided. The text is divided into three sections: (1) Physiology of Exercise, (2) Physiology of Health and Fitness, and (3) Physiology of Performance. Section one (Physiology of Exercise) contains thirteen chapters that provide the necessary background for the beginning student of exercise physiology to understand individually and collectively the role of the major organ systems of the body in maintaining homeostasis during exercise. Indeed, a major theme in section one of the book is that almost all the organ systems of the body work to help maintain a relatively stable internal environment during exercise. Included in section one are chapters covering an overview of biological control systems, bioenergetics and exercise metabolism, endocrine function during exercise, techniques for measurement of work/power, neuromuscular function during exercise, cardiopulmonary responses to exercise, acid-base regulation during work, temperature regulation, and the effects of training on various organ systems.

Sections two and three are devoted to an application of the basic physiological principles contained in section one of the book. Section two (Physiology of Health and Fitness) contains five chapters that include the following topics: (1) factors that limit health and

fitness, (2) work tests used to evaluate cardiorespiratory fitness, (3) training methods for fitness, (4) exercise concerns for special populations, and (5) body composition and nutritional concerns for health.

Section three of the text centers on the physiology of performance. Seven chapters discuss: (1) factors affecting performance, (2) work tests to evaluate performance, (3) training techniques for improvement of performance, (4) training concerns for special populations, (5) nutrition, body composition, and performance, (6) environmental influences on performance, and (7) ergogenic aids. A unique aspect of sections two and three of the book is the inclusion of two chapters on exercise training for special populations. These chapters include discussions of exercise for children, women, asthmatics, diabetics, and epileptics.

## Writing Style

The concepts in this text are presented in a simple and straightforward style. Illustrations and examples are commonly used to clarify or further explain a concept. Technical terms are defined as they are presented since it is assumed that most of the students do not have a strong background in physiology.

## Additions to the Second Edition

Significant additions have been made to several chapters for the second edition of this text. For example, the chapters on bioenergetics, exercise metabolism, hormonal responses to exercise, skeletal muscle, and exercise training have been expanded and significantly updated to reflect a "state of the art" understanding of these key areas of exercise physiology. Further, all other chapters in the text have been updated with new research findings to reflect advances in the field.

## Pedagogical Aids

To help students study and learn the material within *Exercise Physiology*, the following pedagogical devices are included in the text:

1. Each chapter begins with a list of learning objectives.
2. A detailed outline of the topics to be discussed (with page references) is given at the start of each chapter.
3. Key terms to be learned are listed at the front of each chapter.
4. Key terms are highlighted and defined in the text.
5. Most chapters include special or practical applications that are contained within a "box" format. The number of boxes per chapter has been increased in the second edition of the text.
6. An outlined summary is found at the end of each chapter.
7. A list of study questions at the end of each chapter.
8. A suggested reading list and an expanded up-to-date reference list is given at the completion of each chapter.
9. Supplementary appendices.
10. Glossary of terms at the end of the book.

## Ancillary Material

The following materials are available from Brown & Benchmark to supplement the use of this textbook in the teaching of exercise physiology:

1. *Instructors Manual* by Scott K. Powers and Edward T. Howley. The instructor's manual provides a chapter-by-chapter overview of key concepts to be stressed by the instructor as

well as a multiple-choice test bank. The instructor's manual also provides suggestions for laboratory exercises and is free to adopters.

2. *Exercise Physiology Transparency Set.* Transparency acetates are offered free to adopters of the text.

## Acknowledgments

A text like *Exercise Physiology* is simply not the effort of two authors but represents the contributions of hundreds of scientists throughout the world. While it is not possible to acknowledge every contributor to this work, we would like to recognize the following scientists who have greatly impacted our thinking, careers, and lives in general: Drs. Bruno Balke, Ralph Beadle, Ronald Byrd, Ronald Cox, Jerome Dempsey, Stephen Dodd, H. V. Forster, B. Don Franks, Steven Horvath, Henry Montoye, Francis Nagle, Wendell Stainsby, and Hugh G. Welch. Additional thanks are due to the following scholars who reviewed earlier drafts of this volume and offered comments for improvement that we trust they will recognize:

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# Section I

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*Physiology of Exercise*





# Chapter 1

## *Physiology of Exercise in the United States—Its Past, Its Future*

### *Objectives*

**B**y studying this chapter, you should be able to do the following:

1. Name the three Nobel Prize winners whose research work involved muscle or muscular exercise.
2. Describe the role of the Harvard Fatigue Laboratory in the history of exercise physiology in the United States.
3. Describe factors influencing physical fitness in the United States over the past century.

### *Outline*

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Harvard Fatigue Laboratory 4  
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Translation of Exercise Physiology to the  
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