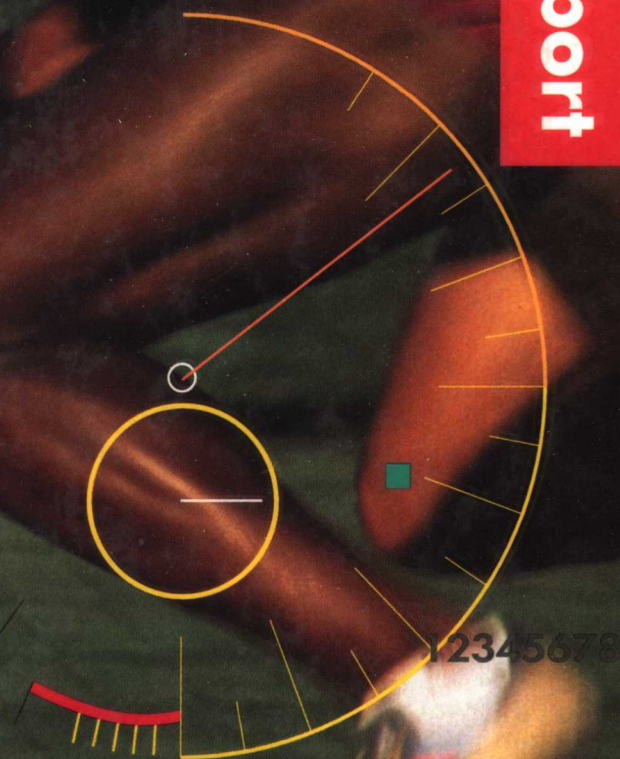


f i f t h e d i t i o n

# The PHYSIOLOGICAL BASIS for

## Exercise and Sport



Edward Fox   Richard Bowers   Merle Foss

f i f t h   e d i t i o n

# The PHYSIOLOGICAL BASIS

for



## Exercise and Sport

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**Dedicated  
to  
our loving wives  
Carolyn Bowers and Peg Foss  
who have each found their  
own successes in exercise and sport**



## P R E F A C E

**I**f you are a past user of the text, the first thing that you will notice is the title change. We have decided to re-title the text, *The Physiological Basis for Exercise and Sport*. The knowledge base and application of concepts have gone well beyond that which existed in 1971 when the first edition of the text was written. The explosion in applications beyond physical education and athletics has given the text a wider audience. While retaining much of the basic knowledge from earlier editions, we have attempted to weave newer applications into the fifth edition.

As with the previous edition, we have been conscious of the legacy that Edward L. Fox (1938–1983) left in the form of this text. We have again tried to preserve the clarity of presentation, the writing style, and tone that have been hallmarks of previous editions. Most importantly, one of our goals has been to write the text for the student rather than for other professors.

This text has been written not only for future physical educators and coaches, but also for students in various other health professions, including physical therapy, occupational therapy, the fitness area, and other applicable fields. Another goal of ours is to provide, through the materials in this text, concepts for safe and sensible conduct of not only sport and physical education programs but also any exercise-based programs.

Major topical additions and updates include material in metabolism, muscle adaptations with training, recovery from exercise, exercise and training for health and fitness, and body composition concepts. Further, chapters 16 and 17 from the previous edition have been combined into a single chapter. While we have not made a wholesale conversion to the International System of Units (Système International d'unités) for units of measurement, we have started the process by making reference to conversion units throughout the text. Selected new illustrations have been added and all of the artwork has, once again, been reworked. Further, for the first time, approximately 50 transparencies and an instructors manual have been added to facilitate the teaching process.

It is our hope that students will be challenged to learn the scientific, or physiological, reasons for training and exercise. In the 1970s, we could not yet say that regular physical activity and being physically fit played a role in longevity. Today, we can. Further, it is our hope that students can themselves eventually challenge current concepts and bring forth new and insightful information.

We would like to thank Scott Spoolman and the staff of Brown and Benchmark for their combined guidance, encouragement, and support throughout the revision process. We also would like to thank

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Thanks also goes to Dr. Fredrick C. "Fritz" Hagerman for support during a critical time in the preparation of the manuscript for this edition of the text. His enthusiasm and dedication are infectious.

Richard W. Bowers

Merle L. Foss



# C O N T E N T S

Preface xv

- 1** Introduction to Sports Medicine, Exercise Physiology, and Kinesiology 2
- What Are Sports Medicine, Exercise Physiology, and Kinesiology? 4
- The Body as a Machine 4
- Overview of the Text 5
- Bioenergetics* 5
- Neuromuscular Concepts* 6
- Cardiorespiratory Considerations* 6
- Physical Training* 7
- Environmental Considerations* 7
- Nutrition and Body Weight Control* 8
- Special Considerations* 8

## S E C T I O N

### 1

#### Bioenergetics

- 2** Energy Sources 12
- Energy Defined 14
- The Biological Energy Cycle 14
- Adenosine Triphosphate—ATP 14
- Sources of ATP* 16
- The Aerobic and Anaerobic Systems during Rest and Exercise* 30
- Summary 37

### 3

#### Recovery from Exercise 42

- Terminology 44
- Recovery Oxygen 44
- Fast and Slow Components* 45
- Replenishment of Energy Stores during Recovery 46
- Restoration of ATP + PC and the Fast Component of Recovery* 46
- Energetics of Phosphagen Restoration* 47
- Muscle Glycogen Resynthesis* 50
- Liver Glycogen Replenishment* 53
- Reduction of Lactic Acid in Blood and Muscle 53
- Speed of Lactic Acid Removal* 54
- Effects of Exercise during Recovery on the Speed of Lactic Acid Removal* 54
- Fate of Lactic Acid—Physiology of Lactic Acid Removal* 56
- Lactic Acid Removal and the Slow Component of Recovery* 57
- Restoration of Oxygen Stores 57
- O<sub>2</sub>-Myoglobin Stores* 57
- Some Practical Recovery Guidelines 58
- Summary 59

### 4

#### Measurement of Energy, Work, and Power 64

- Ergometry 66
- Treadmill* 66
- Stationary Cycle* 66
- Swimming Ergometer* 66
- Other Devices* 66
- Energy, Work, and Power 66
- Energy* 66
- Work* 67
- Power* 68

Direct Measurement of Energy:	
Heat Production	68
Indirect Measurement of Energy:	
Oxygen Consumption	70
The Caloric Equivalence of Oxygen:	
The Respiratory Exchange Ratio (R)	70
Carbohydrate	71
Fat	72
Protein	72
Other Factors Affecting R	73
Measurement of the Energy Cost of Exercise	73
Net Oxygen Cost of Anaerobic Exercise	74
Net Oxygen Cost of Aerobic Exercise	75
Protocols for Assessing Cardiorespiratory Fitness	77
The Concept of the MET	78
Computation of Efficiency	79
Factors Affecting Efficiency	81
Measuring Efficiency on a Cycle Ergometer	81
Measuring Efficiency on a Treadmill	82
Modified Methods for Reflecting Energy Cost	84
Measurement of Energy Cost for the 100-Meter Dash and Other High-Intensity Activities	84
Measurement of Energy Cost for the 400-Meter Race	85
Measurement of Energy Cost Using Telemetry	85
Ancillary Considerations in Measuring Energy Expenditure	87
Body Size and Energy Cost	87
Average Energy and Work Values	87
Summary	88

## S E C T I O N

### 2

## Neuromuscular Concepts

### 5

Skeletal Muscle: Structure and Function	94
Structure—The Basis for Contraction	96
Connective Tissues	96
Tendons	96
Blood Supply	97

Nerve Supply	97
Structure of the Muscle Cell	97
The Sliding Filament Theory of Muscular Contraction	101
Function of Skeletal Muscle	104
The Motor Unit	104
The Motor Unit and Strength Gradations	106
Different Kinds of Motor Units—Fast-Twitch (FT) and Slow-Twitch (ST) Fibers	107
Muscle Force-Velocity and Power-Velocity Relationships	122
Local Muscular Fatigue	124

### 6

## Nervous Control of Muscular Movement 136

Basic Structure of the Nerve	138
Basic Function of the Nerve	138
The Nerve Impulse	138
Nerve-to-Nerve Synapses	140
Nerve-to-Muscle Synapse—The Neuromuscular Junction	143
Muscle Sense Organs	145
Proprioceptors	145
The Muscle Spindle	145
Golgi Tendon Organs	149
Joint Receptors	149
The Nervous System and Motor Skills	150
Voluntary Control of Motor Functions	151
Premotor Area for Learning Specialized Motor Skills	151
Sensory Input and Motor Skills	153
Henry's Memory Drum	154
Summary	155

### 7

## Development of Muscular Strength, Endurance, and Flexibility 158

Weight-Training Programs	160
Muscular Strength: Definition and Types of Contractions	160
Muscular Endurance Defined	166
Physiological Changes Accompanying Increased Strength	166
The Overload Principle	170
Specificity of Weight Training	171
Muscular Soreness	172
Strength and Endurance Programs	175



Flexibility	185
<i>Definition of Flexibility</i>	185
<i>Structural Limits to Flexibility</i>	187
<i>Development of Flexibility</i>	187
<i>Flexibility and Performance</i>	191
Summary	192

## S E C T I O N

### 3

#### Cardiorespiratory Considerations

<b>8</b>	Pulmonary Ventilation	202
	Minute Ventilation	204
	<i>Ventilation at Rest</i>	204
	<i>Ventilation during Exercise</i>	204
	<i>Hyperventilation</i>	206
	<i>Ventilation and the Anaerobic Threshold</i>	207
	<i>Alveolar Ventilation and Dead Space</i>	209
	<i>Standard Lung Volumes and Capacities</i>	211
	<i>Dynamic Lung Measures</i>	213
	<i>Importance of Pulmonary Volumes and Capacities</i>	213
	<i>Second Wind</i>	214
	<i>Stitch in the Side</i>	214
	Ventilatory Mechanics	215
	<i>Movements of the Thoracic Cage—The Respiratory (Ventilatory) Muscles</i>	215
	<i>Oxygen Cost of Ventilation</i>	216
	<i>Pressure Changes</i>	218
	Summary	219
<b>9</b>	Gas Exchange and Transport	224
	Gas Exchange—Diffusion	226
	<i>Partial Pressure of Gases</i>	226
	<i>PO<sub>2</sub> and PCO<sub>2</sub> Gradients in the Body</i>	228
	<i>Other Factors Affecting Gas Exchange</i>	230
	<i>Diffusion Capacity during Exercise</i>	231
	Gas Transport	231
	<i>Transport of Oxygen by Blood</i>	232
	<i>The Oxyhemoglobin Dissociation (or Association) Curve</i>	233

<i>Transport of Carbon Dioxide by Blood</i>	236
<i>Total O<sub>2</sub> and CO<sub>2</sub> Content of Blood</i>	239
Summary	240

## 10 Blood Flow and Gas Transport 242

Blood Flow Changes	244
<i>The Heart and Cardiac Cycle</i>	244
<i>Cardiac Output during Exercise</i>	250
<i>Distribution of Blood Flow</i>	255
<i>The Oxygen Transport System</i>	258
Circulatory Mechanics—Hemodynamics	258
<i>Blood Pressure</i>	258
<i>Resistance to Flow</i>	260
<i>Changes in Pressure and Resistance during Exercise</i>	260
Summary	262

## 11 Cardiorespiratory Control 266

Summary of the Cardiorespiratory System	268
The Respiratory and Cardiovascular Areas	269
<i>Stimulation of the Cardiorespiratory Areas</i>	269
<i>Innervation of the Cardiorespiratory Apparatus</i>	271
<i>Cardiorespiratory Control at Rest and during Exercise</i>	273
Summary	281

## S E C T I O N

### 4

#### Physical Training

<b>12</b>	Methods of Physical Training	286
	General Considerations	288
	<i>Training Principles</i>	288
	<i>Training Phases</i>	296
	<i>Preliminary Exercise (Warm-Up)</i>	297
	<i>Warm-Down or Cool-Down</i>	299
	Training Methods	299
	<i>Interval Training</i>	300
	<i>Continuous Running</i>	307
	<i>Repetition Running</i>	309

<i>Speed Play or Fartlek Training</i>	309
<i>Sprint Training</i>	311
<i>Interval Sprinting</i>	311
<i>Acceleration Sprints</i>	311
<i>Hollow Sprints</i>	311
Application of Training Methods to Various Sports	311
Summary	314

## 13 Physiological Effects of Physical Training 320

Training Effects	322
<i>Biochemical Changes</i>	322
<i>Cardiorespiratory (Systemic) Changes</i>	327
<i>Other Training Changes</i>	342
Factors Influencing Training Effects	344
<i>Intensity of Training</i>	344
<i>Frequency and Duration of Training</i>	345
<i>Specificity of Training Effects</i>	348
<i>Genetic Limitations</i>	352
<i>Mode of Exercise</i>	354
<i>Maintenance of Training Effects</i>	355
Summary	359

## 14 Exercise and Training in Females 368

Performance Records	370
Body Size and Body Composition	372
<i>Weight and Height</i>	372
<i>Body Fat</i>	372
<i>Possible Body Structure Differences</i>	374
<i>Age and Body Size Differences</i>	374
Performance-Matched Physiological Characteristics	375
The Energy Systems	375
<i>The ATP-PC System</i>	375
<i>The Lactic Acid System (Anaerobic Glycolysis)</i>	376
<i>The Oxygen (Aerobic) System</i>	377
Strength	380
<i>Strength Differences</i>	380
<i>Effects of Weight Training</i>	383
Physical (Aerobic) Trainability	387
<i>Training Frequency, Duration, and Intensity</i>	387

<i>Physiological Changes Following Training</i>	387
Gynecological Considerations	391
<i>Menstruation</i>	391
<i>The Breast, Reproductive Organs, Pregnancy, and Childbirth</i>	397
Guidelines for Female Participation in Sports	400
Summary	401

## 15 Exercise and Training for Health and Fitness 410

Causes and Risk Factors of Cardiovascular Diseases	412
<i>Causes of Heart Attack</i>	412
<i>Risk Factors Associated with Heart Attack</i>	413
<i>What Is Your Coronary Heart Disease Risk?</i>	418
<i>Stroke and Hypertensive Diseases</i>	421
Lipid Hypothesis for Atherosclerosis	422
<i>Controversial Issues</i>	422
<i>National Cholesterol Education Program (NCEP)</i>	423
<i>Estimation of LDL-Cholesterol</i>	423
<i>Effectiveness of T-Chol Screening</i>	424
Effects of Exercise and Training on Health and Fitness	425
<i>Coronary Collateral Vascularization</i>	426
<i>Vessel Size</i>	426
<i>Blood Clotting Capability</i>	427
<i>Blood Cholesterol (Lipid) Levels</i>	427
<i>Blood Pressure</i>	428
<i>Vulnerability to Cardiac Dysrhythmias</i>	429
The Exercise Prescription	429
<i>Medical Evaluation</i>	429
<i>Quantity and Quality of the Exercise Program</i>	431
<i>Warm-Up and Warm-Down</i>	436
Exercise and Special Populations	437
<i>Hypertensives</i>	437
<i>Diabetics</i>	437
<i>The Obese</i>	438
<i>Children/Adolescents</i>	438
<i>Elderly</i>	438
Summary	439

## S E C T I O N

## 5

**Environmental  
Considerations**

- 16** Diffusion, Osmosis, Scuba, and Performance at Altitude 448
- The Cell 450
- Diffusion* 450
  - Facilitated Diffusion* 450
  - Osmosis* 451
  - Electrical Forces* 452
  - Active Transport* 453
- Effects of Changes in Pressure and Temperature on Gas Volumes 454
- Effects of Pressure Changes on Gas Volume* 454
  - Effects of Temperature Changes on Gas Volume* 454
  - Weight of Air and Water* 454
  - Effects of Pressure and Concentration on Gas Absorption* 455
- Physical and Physiological Principles of Scuba 456
- Air Embolus* 456
  - Spontaneous Pneumothorax (Spontaneous Entrance of Air into the Pleural Cavity)* 457
  - Nitrogen Narcosis (Raptures of the Deep)* 457
  - The Bends* 458
  - Oxygen Poisoning* 459
  - Squeeze* 460
  - Aerotitis* 460
  - Underwater Breathing Systems* 460
- Performance at Altitude 461
- Altitude Acclimatization* 461
  - Athletic Performance at Altitude* 463
  - The Oxygen Dissociation Curve and Altitude* 466
  - Training and Altitude* 467
- Summary 468

- 17** Heat Balance: Exercise in the Heat and Cold 472

- Heat Balance 475
- Heat Exchange* 475
  - Heat Production (Gain)* 477
  - Mechanisms of Heat Exchange* 477
- Temperature Regulation 479
- Thermal Receptors* 479
  - Thermal Effectors* 479
  - The Thermal Regulatory Center* 480
- Exercise in the Heat and Heat Disorders 480
- Exercise in the Heat* 482
- Heat Disorders in Athletics 483
- Football* 485
  - Other Sports* 486
- Prevention of Heat Disorders 488
- Salt and Water Replacement* 488
  - Acclimatization to Heat* 491
  - Clothing and Environment* 492
  - Emergency Care in Heat Illness* 496
- Exercise in the Cold 496
- Responses to Cold* 497
  - Windchill* 500
  - Acclimation and Acclimatization* 503
- Training in the Cold 504
- Summary 504

## S E C T I O N

## 6

**Nutrition and Body  
Weight Control**

- 18** Nutrition and Exercise Performance 512
- Nutrients 514
- Carbohydrates* 514
  - Fats* 515
  - Proteins* 516
  - Vitamins and Minerals* 519

Food Requirements	521
<i>Selecting Foods</i>	523
<i>Number of Meals</i>	524
<i>Diet before Activity: The Pregame Meal</i>	524
<i>Diet during Activity: Replacement of Sugar and Water</i>	526
<i>Diet following Activity</i>	527
<i>Can Diet Affect Performance?</i>	528
Summary	532

<b>19</b>	Exercise, Body Composition, and Weight Control	538
	Body Composition	540
	<i>The Sheldon Somatotype</i>	540
	<i>Heath-Carter Anthropometric Somatotype</i>	541
	<i>Somatotype and Physical Activity</i>	542
	<i>Body Fat: Concepts and Assessment</i>	542
	<i>Assessment Methods for Body Composition</i>	545
	<i>What Is a Desirable Body Composition?</i>	550
	<i>What Is a Desirable Body Weight?</i>	550
	Body Weight Control	551
	<i>Obesity</i>	551
	<i>Energy Balance and Weight Control</i>	553
	<i>Making Weight in Wrestling</i>	559
	<i>The Iowa Studies</i>	560
	<i>The Midwest Wrestling Study</i>	563
	<i>ACSM Guidelines for Weight Loss in Wrestlers</i>	564
	<i>Women Gymnasts</i>	564
	<i>Summary of Body Composition Assessment Processes</i>	565
	Exercise and Training Effects	566
	<i>Exercise Classes</i>	566
	<i>Training Programs</i>	567
	<i>Sports Specific Responses</i>	568
	<i>Children and Fatness</i>	568
	<i>Aging and Fatness</i>	569
	Summary	569

## S E C T I O N

### 7

## Special Considerations

<b>20</b>	Exercise and Acid-Base Balance	576
	Acids and Bases	578
	<i>Buffers</i>	578
	<i>pH (Power of the Hydrogen Ion)</i>	578
	Respiratory Regulation of pH	579
	<i>Alkali Reserve</i>	579
	The Kidney and Acid-Base Balance	580
	<i>Alkalosis and Acidosis</i>	581
	Acid-Base Balance Following Heavy Exercise	581
	Summary	583
<b>21</b>	Exercise and the Endocrine System	586
	Characteristics of Hormone Action	588
	<i>Specificity of Hormone Action</i>	588
	<i>Mechanisms of Hormone Action</i>	588
	<i>Control of Hormone Secretion</i>	589
	<i>The Hormones and Their Glands</i>	590
	Hormonal Responses to Exercise and Training	597
	<i>Growth Hormone (GH)</i>	598
	<i>Thyroid and Parathyroid Hormones</i>	598
	<i>Antidiuretic Hormone (ADH) and Aldosterone</i>	599
	<i>Insulin and Glucagon</i>	600
	<i>The Catecholamines: Epinephrine and Norepinephrine</i>	601
	<i>The Sex Hormones</i>	602
	<i>The Glucocorticoids (Cortisol) and Adrenocorticotrophic Hormone (ACTH)</i>	604
	<i>Prostaglandins and Endorphins</i>	605
	<i>Hormonal Response Combinations</i>	605
	Summary	606

**22** Drugs and Ergogenic Aids 612

Ergogenic Aids Defined 614

Problems in Research Design 614

Nutrition Aids 615

*Carbohydrates* 615*Water and Electrolytes* 616*Vitamins and Minerals* 616

Pharmacological Agents 617

*Anabolic-Androgenic Steroids* 617*Growth Hormone* 618*Amphetamines* 618*Alkaline (Bicarbonate) Ingestion* 620*Caffeine* 620*Pangamic Acid (Vitamin B-15)* 621

Physiological Agents 621

*Blood Doping* 621*Oxygen* 622

Sports and Drug Testing 623

Summary 623

**A** Selected Symbols and Abbreviations 629**B** Pulmonary Symbols and Norms 631**C** The Gas Laws 635**D** Calculation of Oxygen Consumption and Carbon Dioxide Production 641**E** Nomogram for Calculating Body Surface Area and Body Weight in Kilograms from Pounds 647**F** Group Interval Training Programs for Unconditioned College Men and Women 651**G** Tests of Anaerobic and Aerobic Power 657**H** Procedures for the Heath-Carter Anthropometric Somatotype Method 669**Glossary** 675**Credits** 695**Index** 698

# The PHYSIOLOGICAL BASIS for **Exercise and Sport**

# Introduction to Sports Medicine, Exercise Physiology, and Kinesiology

# 1

Today more than ever before it is necessary for physical educators, coaches, trainers, and fitness instructors to recognize the vital part *science* plays in the successful conduct of physical education, athletic, and activity programs. Over the past 30 years the number of exercise physiology laboratories has increased tremendously. As a result much new knowledge dealing with how best to train athletic teams and to develop fitness for health has appeared in the scientific literature.

Further evidence of advancement in the scientific area of physical education and athletics was the formation of the American College of Sports Medicine (ACSM) in 1954. The college membership is made up of physical educators, athletic trainers, coaches, exercise physiologists, physicians, nutritionists, and numerous other interested professional groups. Membership in the college rose to 3000 from 1954 to 1975, and then doubled to over 6000 between 1975 and 1978. Now with over 13,000 members, the American College of Sports Medicine is the largest and most influential sports medicine group in the world. In 1984, the ACSM National Center was moved from Madison, Wisconsin, to Indianapolis, Indiana. There also are ten regional chapters located throughout the United States. The national ACSM organization meets once a year, at which time research papers covering all aspects of the science of sports and exercise are presented. *Medicine and Science in Sports and Exercise*, published monthly by the College, is an international journal containing research articles dealing with all facets of sports medicine. The ACSM also publishes position stands and

opinion statements on specific topics and public issues and offers certification programs for Exercise Leaders, Exercise Test Technologists, Exercise Specialists, and Exercise Program Directors as well as Health Fitness Instructors and Health Fitness Directors.

Another example of the ever-increasing interest in sports medicine was the formation of the Committee on the Medical Aspects of Sports in 1959, an organization of the American Medical Association. This group does an excellent job in disseminating literature concerned with protecting the health of the athlete as well as holding seminars for coaches, trainers, and physicians.

The Association for Fitness in Business (AFB), formerly called the American Association of Fitness Directors in Business and Industry, was organized in 1974 to meet the growing need of a variety of professionals and their support staffs who began to develop worksite fitness and health promotion programs. The AFB holds a national conference each year and also has developed a network of ten regional chapters and international affiliates to disseminate information regarding promotion and management of programs in corporate, hospital, private, and community settings.

Still other organizations about which the informed student should be aware are the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD), the United States Olympic Committee (USOC), the President's Council on Physical Fitness and Sports (President's Council), and the Federation Internationale de Medicine Sportive



(FIMS). Student membership is available in ACSM, AFB, and AAHPERD, whereas appointment to the other groups is necessary for direct involvement.

For you to contribute to the best of your ability to all aspects of physical education, athletics, and fitness leadership will require a good understanding of the available scientific knowledge. Such understanding will not only result in better teams and better programs of activities, but also enable you to guard the health of your students, athletes, and clients, which is one of your primary responsibilities. Then too, knowing the reasons *why* you select a particular approach for accomplishing

a specific task immediately establishes you as a professional rather than a technician.

The recent and rapid expansion of knowledge and interest in sports medicine requires that you learn much more factual and technical information than your predecessors. At the same time, you are favored by having a greater number of career opportunities open to you. There are few career tracks today that offer more variety, personal challenge, and opportunity for service than those related to the educational, scientific, and clinical aspects of sports medicine and exercise science.

## ■ What Are Sports Medicine, Exercise Physiology, and Kinesiology?

### ■ The Body as a Machine

#### Overview of the Text

Bioenergetics  
 Neuromuscular Concepts  
 Cardiorespiratory Considerations  
 Physical Training  
 Environmental Considerations  
 Nutrition and Body Weight Control  
 Special Considerations



The major concepts to be learned from this chapter are as follows:

- Comprehension of exercise physiology is important for physical educators, coaches, trainers, and fitness instructors.
- *Sports medicine* is a term that refers to all aspects of sport and exercise science.
- Because of recent research and an upsurge of interest in physical fitness, health, and wellness, today's young professionals are faced with increased learning challenges and career opportunities.
- *Exercise physiology* is an aspect of kinesiology and sports medicine that involves the study of how the body, from a functional standpoint, responds, adjusts, and adapts to exercise.
- *Kinesiology* is a broad, umbrella term that means the scientific study of human movement. This includes such aspects of study as exercise physiology, motor learning/control, and biomechanics.
- There are reasons to be in awe of the performance capabilities of the human body when viewed as a working "machine."
- Both the older *systems approach* and the more recent emphasis on *cellular biology* are important to better understanding its functions and limitations. This is the challenge of the future.

## What Are Sports Medicine, Exercise Physiology, and Kinesiology?

In the preceding discussion, the terms *sports medicine* and *exercise physiology* were mentioned several times. These terms may have different meanings to different people, so let's define them here. In the United States, sports medicine is an all-encompassing term that refers to all aspects, not just medical, of sport and exercise. Examples of such aspects would be (1) athletic medicine, (2) biomechanics, (3) clinical medicine, (4) growth and development, (5) psychology and sociology, (6) nutrition, (7) motor control, and (8) physiology. This latter aspect is synonymous with exercise physiology or the physiology of exercise. As the term implies, this aspect of sports medicine involves the study of how the body, from a functional standpoint, responds, adjusts, and adapts to exercise. This includes acute exercise (i.e., single bouts of exercise) as well as chronic or prolonged exercise, as is the case with exercise training. In other words, exercise physiology provides the physiological basis of physical education, fitness, and athletic programs.

The term *kinesiology* has undergone some changes in usage and deserves some clarification of its current definition. Its root meaning is from the Greek word *kinein* (to move), which is combined with *-logy* from the Greek word *-logia*, which means a science, doctrine, or theory of some topic. For our common use, *kinesiology means the scientific study of movement*. Kinesiology, at one time, was taught as a single course within most college and university physical education curriculums and included material now covered in biomechanics classes. Another change in the use of the term *kinesiology* is more widespread. During the late 1980s, many Physical Education units at institutions of higher learning in the United States and Canada changed their names to Kinesiology or some derivation thereof. This elevated the term to a higher level of usage and denoted a broader definition. It also placed an important burden on physical education practitioners to be certain that the ever-important traditional aspects of this curriculum were not lost in the transition process.

## The Body as a Machine

Although humanists might take issue with an engineering approach that views the body as a "working machine," doing so has a number of advantages and justifications. First, the learner can relate physiological functions to the workings of other devices that they may have experienced in the more observable world of machines. For example, a basic understanding of how fluids are circulated under pressure in the closed cooling system of a car allows an easier appreciation of how the body adjusts to remain cool during the performance of work. Likewise, a basic knowledge of cellular metabolic functions allows a better understanding of the production sites and quantities of useful and bothersome heat produced during exercise. A combination of these thought processes allows the well-informed analyst to diagnose and reasonably predict the effects of any compromised function by parts common to both machines. By way of example, would covering the radiator of a car and the skin of a human body with blankets on a hot day not have a similar effect on core temperature if their "motors" were kept running? The temperatures of both "machines" would increase primarily because of the continued production and circulation of nonusable heat in unfavorable conditions for dissipating the heat load.

The foregoing analogy makes the point that a knowledge of both systems physiology and cellular biology are important to our contemporary understanding of how the body works. Although most of the systems aspects have been worked out and are reasonably well understood, the future of exercise physiology, as an academic discipline, resides in our understanding of cellular and subcellular *mechanisms* (note this choice of words which is used throughout biology). For this reason, students are encouraged to think at both levels but to ever increase their depth of knowledge about cellular processes.

With this in mind and going back to thoughts of the human body as a machine, there may be little wonder why many exercise scientists are awed by the human body's potential performance capabilities. World records substantiate that it allows both impressive sprint (100 meters in about 10 seconds) and long-distance