Jeffrey A. Potteiger

AMERICAN COLLEGE of SPORTS MEDICINE
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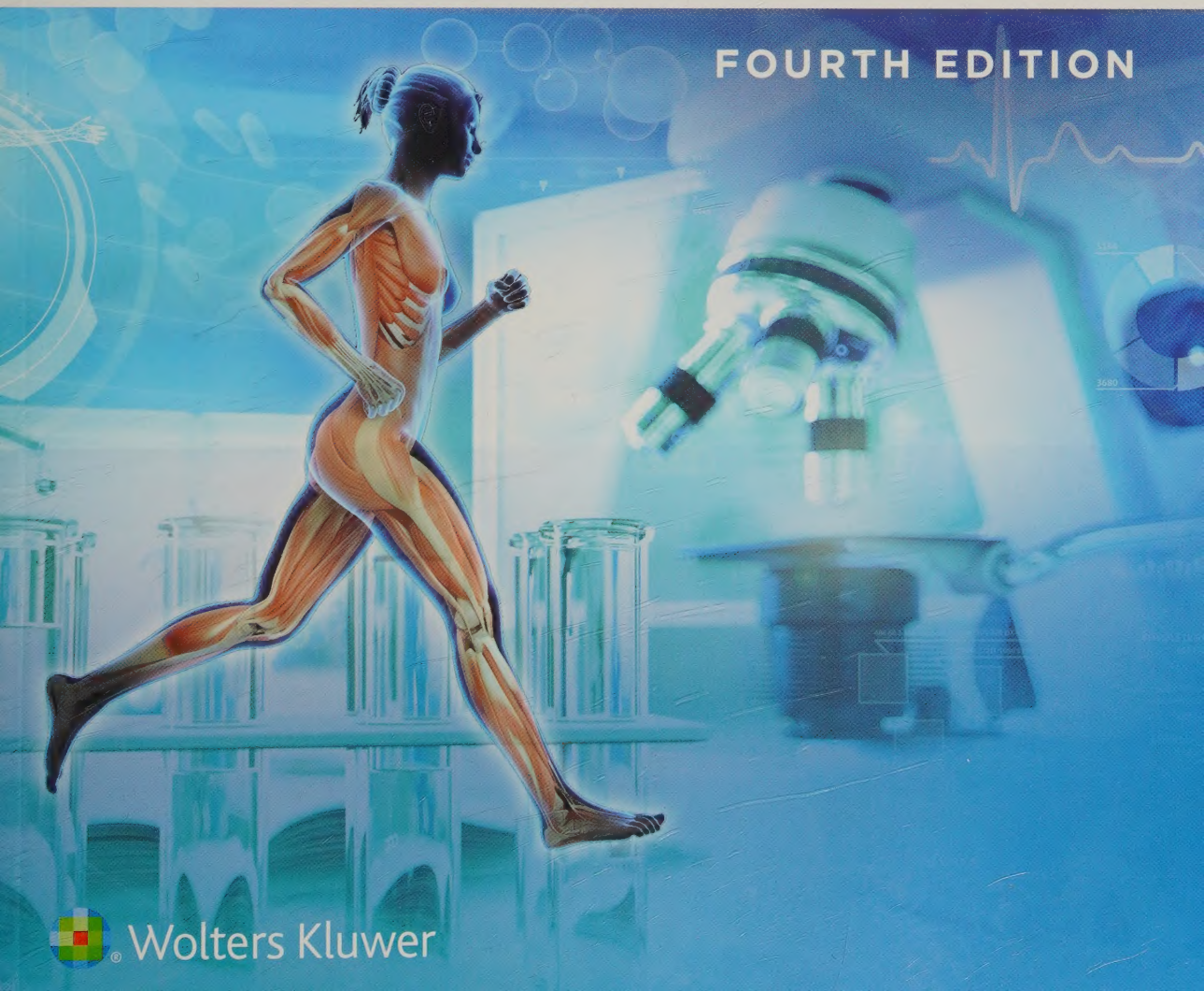
ACSM'S Introduction to EXERCISE SCIENCE

FOURTH EDITION



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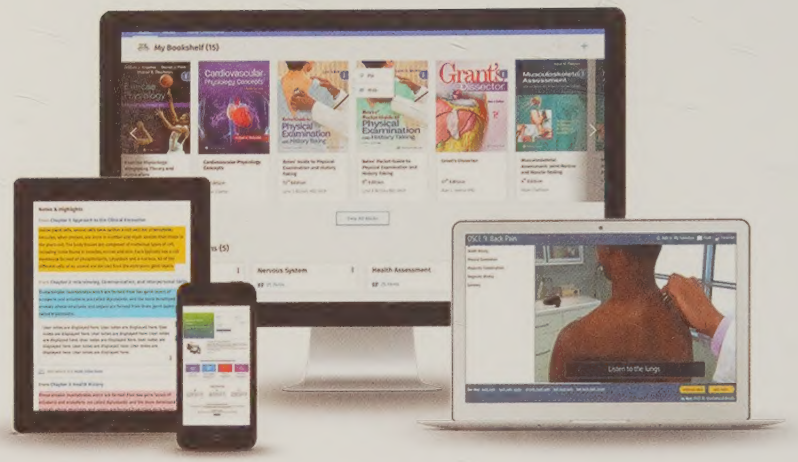

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Grand Valley State University
Grand Rapids, Michigan

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To
Ellen**, **Tate**, and **Caroline
for their never-ending support and love

Preface

Exercise science is an umbrella term used to describe the study of numerous aspects of physical activity, exercise, sport, and athletic performance that have the common characteristic of movement and the adaptations that occur as a result of physical activity, regular exercise, and training and performing in sport and athletic competition. The study of the physiological, psychological, nutritional, motor, and functional adaptations and responses to physical activity, exercise, sport, and athletic competition is key to understanding human health, disease, injury, rehabilitation, and performance. Physical activity and regular exercise play very important roles in promoting overall health and healthy living and reducing the risk for numerous lifestyle diseases. Proper physical training and preparation are crucial for maximizing individual and team performance in sports and athletic competitions, for reducing the risk of injury, and to assist in the rehabilitation and recovery from an injury. Exercise science students must, therefore, be well prepared for understanding how human movement assists individuals in their pursuit of good health and successful sport performance.

ACSM's Introduction to Exercise Science provides an overview of the components important to developing a solid foundation and appreciation of all aspects of exercise science. This book is designed for first-year students in exercise science or any of the related areas, including athletic training and sports medicine, clinical and sport biomechanics, clinical exercise physiology, exercise and sport nutrition, exercise physiology, exercise and sport psychology, and motor development, control, and learning. The 13 chapter topics and content were chosen to represent both the foundational and the broad-based professional areas and issues of exercise science.

Features

Learning Objectives at the beginning of each chapter highlight concepts of importance. Boxes throughout the chapters also highlight important **terms and their definitions**, helping students to identify immediately terminology that may be new or unfamiliar. **Interviews** with prominent exercise science professionals are featured within each chapter; these individuals provide helpful insight into proper preparation for developing a successful professional career. **Critical Thinking Questions** are placed throughout the chapters as well to help facilitate discussion and deeper application of concepts. **Review Questions** at the end of each chapter provide an opportunity for a brief review of the material covered. **Project-Based Learning** assignments help students gain knowledge by working on a topic of practical application that will reinforce understanding and comprehension of the material covered in each chapter. **Figures, tables, and illustrations** support and help explain the content information provided in the chapters.

Supplemental Materials

Supplemental materials available on thePoint for instructors include:

- PowerPoint Lecture Outlines
- Image Bank, including all figures and tables from the text
- Test Bank

For students, flash cards and videos are available.

This book is designed to provide beginning students with an overview of the foundational content within the areas of exercise science as well as options available for professional career opportunities, career development, and employment. A look into the future focuses on several key paths that exercise science may take in the next 20 years. I hope that this book provides students with valuable insight as they explore the wonderful world of the human body.

Acknowledgments

I wish to extend a heartfelt thank you to all my professional colleagues and former students who shared their thoughts and insights with me about the content and direction of this textbook. I would like to specifically acknowledge all of my ACSM colleagues, for their support and belief in me, and Ellen E. Adams, for her critical review of the material.

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Contents

CHAPTER

1

Introduction to Exercise Science

After completing this chapter, you will be able to:

1. Explain the importance of exercise science as it relates to enhancing our understanding of health, physical activity, exercise, sport, and athletic performance.
2. Identify the different disciplines, subdisciplines, and specialty areas of exercise science, and describe how they relate to exercise science.
3. Describe the key highlights in the historical development of exercise science.
4. Identify the key influential accomplishments of the American College of Sports Medicine for promoting exercise science.
5. Recognize the general and advanced undergraduate coursework necessary for a career in an exercise science or health care profession.

Physical activity, exercise, sport, and athletic performance are integral parts of so many societies and cultures around the world. Some of our earliest recordings of history mention the importance of physical activity and health. For example, many of the Greek philosopher Aristotle's teachings describe the significance of physical health to a good life (1). Indeed, there is considerable research evidence that supports the role of being physically active and participating in regular exercise for promoting good **health** and decreasing the risk of **morbidity** and **mortality** (2–11). Despite this information, the morbidity and mortality rates from lifestyle-related diseases remain high (12). Figure 1.1 shows the most common causes of mortality in the United States for the year 2017 (12). For many of the disease conditions contributing to early mortality, there is a lifestyle component that can be significantly affected by regular participation in physical activity and exercise.

In developed countries of the world, the changing work and living environment has for some people resulted in a decrease in physical labor and work activity, but at the same time an increase in the opportunity for participation in leisure time activities (13–15). Despite this increase in free time, many individuals in the general population do not exercise enough or are insufficiently physically active to promote and maintain good health and reduce disease risk (5). For example, Figure 1.2 shows the percentage of adults who met the Physical Activity Guidelines for aerobic physical activity, muscle-strengthening activity, and aerobic and muscle-strengthening activity for 2018 (16). While many individuals are regularly engaging in physical activity and exercise, there is still a significant number who do not participate in any type of structured physical activity. Partly as a result of the high

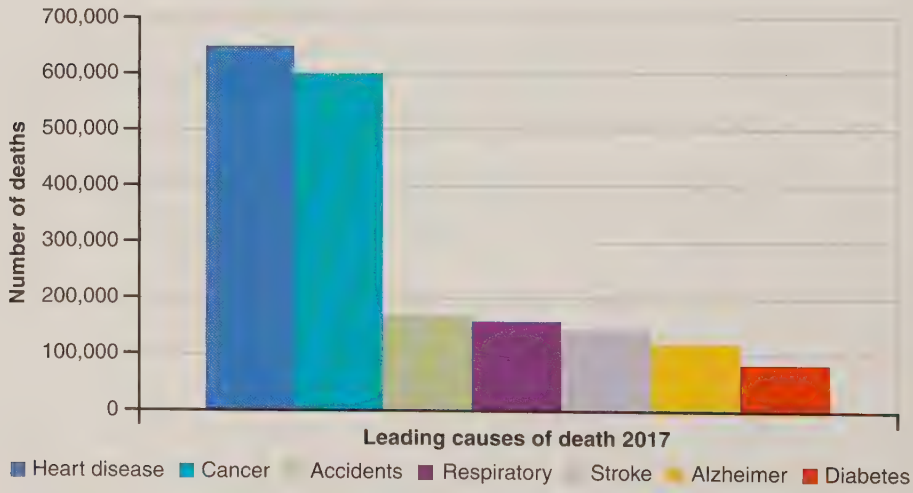

FIGURE 1.1 Common causes of mortality in the United States for the year 2017 (12).

Health A state of complete physical, mental, and social well-being; not simply the absence of disease.

Morbidity The relative incidence of a particular disease.

Mortality The rate of death in a population.

levels of physical inactivity, the United States and other countries have experienced a dramatic increase in the number of individuals who are overweight or obese, prompting health care experts to declare an obesity epidemic earlier this century (17,18). Figure 1.3 illustrates the age-adjusted prevalence of overweight and obesity among the U.S. adults aged 20 to 74 years as reported by the National Health and Nutrition Examination Surveys (NHANES) (19–23). There has also been a rise in other disease and health conditions linked to a lack of physical activity and exercise. For example, an individual's risk level for high blood pressure, Type 2 diabetes, cardiovascular disease, osteoporosis, certain forms of cancer, depression, and anxiety can be affected by the amount of physical activity and exercise in which

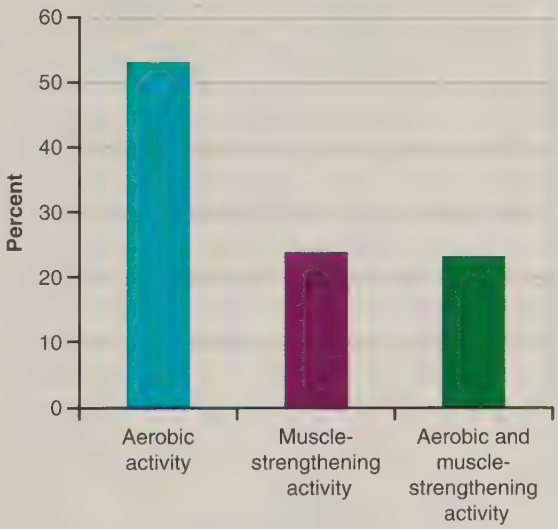

FIGURE 1.2 Percentages of U.S. adults aged 18 years and older who met the physical activity guidelines for aerobic, muscle-strengthening, and aerobic and muscle-strengthening activity for the year 2018 (16).

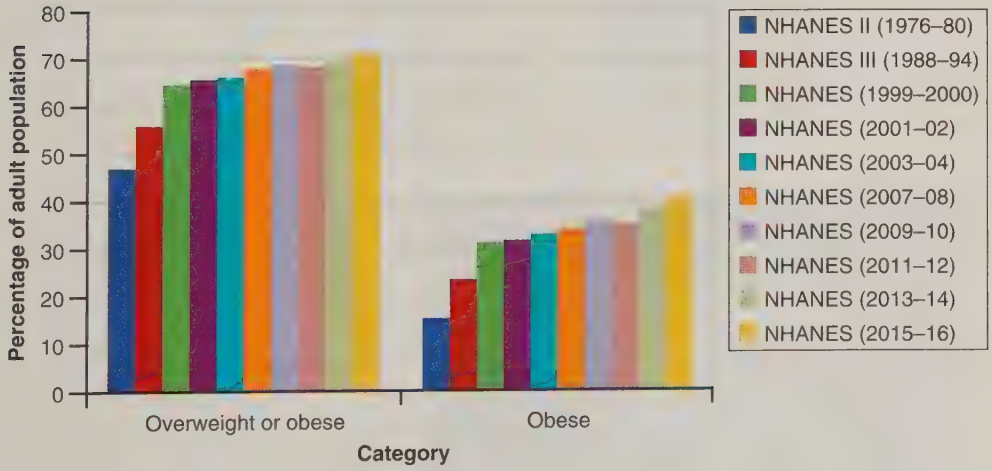

FIGURE 1.3 Age-adjusted prevalence of overweight and obesity among U.S. adults, aged 20 to 74 years as reported by the National Health and Nutrition Examination Surveys (NHANES) (19,20,21,22,23,59,60).

an individual participates (6,24–28). Therefore, exercise science professionals have an extremely important responsibility in helping individuals understand the importance of physical activity and exercise in promoting physical fitness and health, how to personally design and implement effective fitness and exercise programs, and the best practices for preventing and recovering from injury.

Throughout history, the ability to succeed in sport and athletic competition have been highly valued by people and societies. The ancient Greeks held physical prowess and successful athletes in high regard. The importance of athletic competition was so revered that regularly scheduled Olympic Games were held in Greece from 776 BC until 393 AD (29). Early sports and athletic competitions primarily involved individual events such as wrestling and running and often emerged from activities related to obtaining food (*e.g.*, javelin throwing) or personal survival (*e.g.*, boxing) (30). As societies and cultures continued to develop, sports and games that often started from activities initiated in the rural working class became increasingly popular (30). In modern society, we have the Winter and Summer Olympic and Paralympic Games (Figure 1.4) alternating on a 2-year cycle, as well as regularly scheduled national and international athletic competitions. Professional, college, high school, amateur, club, and recreational sporting events are an integral part of our social fabric binding communities, societies, and cultures together. There are more opportunities for individuals of all ages to participate in sporting events and athletic competitions than ever before. For example, the number of individuals participating in high school athletics has increased to over 7.9 million students in 2018–19 (Figure 1.5) (31). This upward trend in participation has also continued at the college and university level. According to the National Collegiate Athletic Association (NCAA), the number of students participating in intercollegiate sports has increased by over 260,000 participants, including 146,000 women, from the 1982 to 2018–19 academic year (Figure 1.6) (32). Countless other individuals of all ages are participating in professional, amateur, club, and recreational sport and athletic competitions each year.

Athletes and coaches are continuously looking for exercise science professionals to assist them in developing effective training programs, the safest and most advantageous equipment and techniques, a sound nutritional diet, appropriate mental health strategies, and the best treatments for their acute and chronic injuries: all in an effort to improve their performance. Unfortunately, the desire and pressure to succeed has created a culture of win at all cost for some individuals, leading to performance-enhancing drug use and other

FIGURE 1.4 The Summer and Winter Olympic and Paralympic Games are held every 2 years. (Shutterstock.)

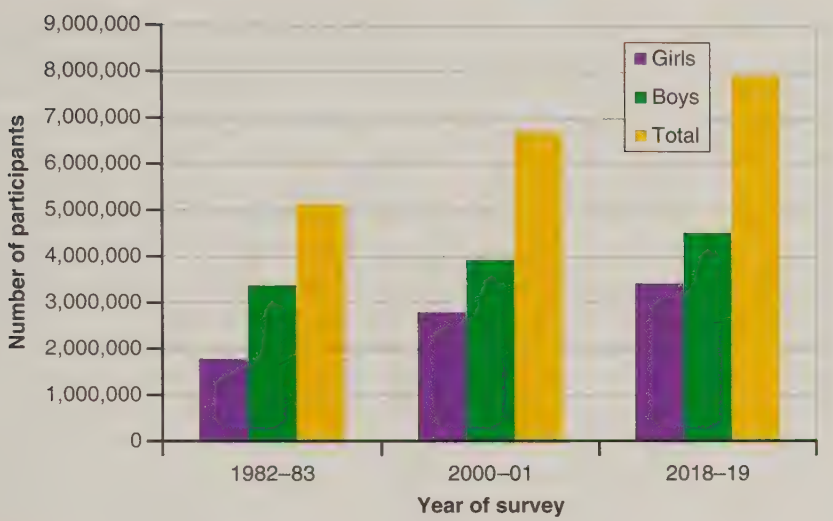

FIGURE 1.5 Number of individuals participating in high school athletics (31).

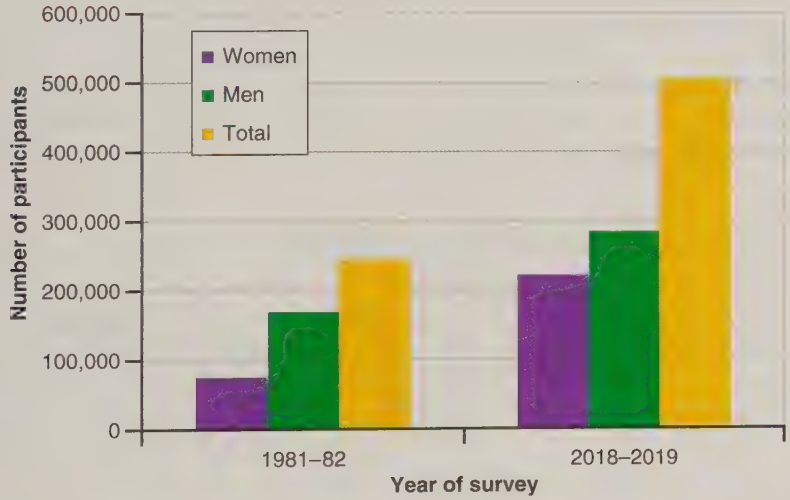

FIGURE 1.6 Number of individuals participating in NCAA-sponsored intercollegiate athletics (32).

forms of cheating during training and competition. For example, reports indicate as many as 5.4% of male and 2.9% of female adolescents have used androgenic anabolic steroids (33) and that lifetime prevalence use rates for males and females is around 6.4% and 1.6%, respectively (34). More recent evidence indicates that the prevalence of current and prior androgenic anabolic steroid users was as high as 16.9% in men and 6.5% in women (35). Each year, athletes of all ages are disqualified from participation and competition in sports because of using performance-enhancing drugs and other banned substances. Exercise science professionals can play a vital role in promoting safe and fair training methods for athletes at all ages and levels of competition.

The benefits derived from regular participation in physical activity and exercise and the involvement in sport and athletic competition are important to us personally and as a society. Individuals can gain improvements in physical, mental, and social health, and society gains from reduced levels of lifestyle diseases and illness. Exercise science professionals play an important role in promoting individual and population health, physical activity, and exercise, and contributing to successful performance in sport and athletic competition. These exercise science professionals include exercise and clinical exercise physiologists, athletic trainers, sports medicine physicians, exercise and sport nutritionists, clinical and sport biomechanists, exercise and sport psychologists, and motor behavior specialists, among others. These professionals contribute to promoting good physical activity and exercise habits, reducing injury and disease risk, and assisting those individuals participating in sports and athletic competition in a wide variety of ways.

As you read through the chapters of this textbook, you will realize that each area of study and profession in exercise science has movement as a central theme or focus. Therefore, it is worthwhile at this point to operationally define these different types of movement. **Physical activity** includes those movement activities of daily living such as work- and job-related activities, leisure time activities, and activities performed around the home. Sufficient levels of physical activity can result in improvements of fitness and health. **Exercise** is a structured movement process that individuals consciously and voluntarily engage in. Exercise includes those activities that improve or maintain fitness and health and those activities that improve performance in a sport or athletic competition. **Sport and athletic competition** are defined as movement in structured and organized activities that consist of a competitive aspect including all individual and team athletic events. Combined, these types of movement activities are at the center of the study and professional practice of exercise science.

WHAT IS EXERCISE SCIENCE

Many scholars and professionals have a difficult time agreeing on a definition of exercise science. For the purpose of this textbook, **exercise science** will be used to describe the study of various aspects of physical activity, exercise, sport, and athletic performance that have the common characteristic of physical movement and the adaptations that occur as a result of

Physical activity Movement activities of daily living, including work- and job-related activities, leisure time activities, and activities performed around the home.

Exercise A structured movement process that individuals consciously and voluntarily engage in and includes those activities that improve or maintain fitness and health.

Sport and athletic competition Movement in structured and organized activities that include a competitive aspect including all athletic events.

Exercise science An umbrella term used to describe the study of numerous aspects of physical activity, exercise, sport, and athletic performance that have the common characteristic of movement and the adaptations that occur as a result of physical activity and regular exercise.

participation in physical activity and regular exercise. The term exercise science has evolved primarily from the disciplines of physical education and exercise physiology to be much more inclusive of related areas of study and professions. Exercise science broadly includes the behavioral, functional, nutritional, physiological, psychological, and structural adaptations to movement. Over time we have seen exercise science become part of our educational and professional activities so that we now have Departments of Exercise Science in our colleges and universities, curricular programs of exercise science that can gain accreditation from national organizations, and students graduating with undergraduate and/or graduate degrees in exercise science. Kinesiology is another term commonly used to describe the study of movement. Kinesiology generally reflects a more broadly defined study of movement including the components of exercise science and the additional areas of physical education, sport history, and sport sociology. Departments or Schools of Kinesiology often include professional areas of study such as sport management, sport marketing, sport leadership, and sport journalism. Exercise science is more commonly used to reflect study, preparation, and professional practice in both basic science and applied science areas that are specifically related to health, physical activity, exercise, sport, and athletic competition.

Areas of Study in Exercise Science

An academic discipline is defined as an organized formal body of knowledge (36). Generally, in most academic disciplines the body of knowledge is limited to a specific subject matter. For example, the traditional academic areas of biology, chemistry, and mathematics are defined as disciplines because they have specific bodies of knowledge. Each of these disciplines has developed subdisciplines or specialty areas such as plant biology, nutritional biochemistry, and biostatistics. As the traditional academic disciplines have evolved, there is continuing development of subdisciplines and specialty areas. Determining whether exercise science is a specific academic discipline such as chemistry or mathematics is beyond the scope of this textbook. It is clear that related areas in exercise science such as exercise physiology and exercise and sport psychology have been recognized as disciplines (37) because each contains a distinct body of knowledge that is organized in a formal course of learning. In this textbook, exercise science is used as an umbrella term to include exercise and clinical exercise physiology, athletic training and sports medicine, exercise and sport nutrition, exercise and sport psychology, motor behavior, and clinical and sport biomechanics. Figure 1.7 illustrates the disciplines and subdisciplines covered under the exercise

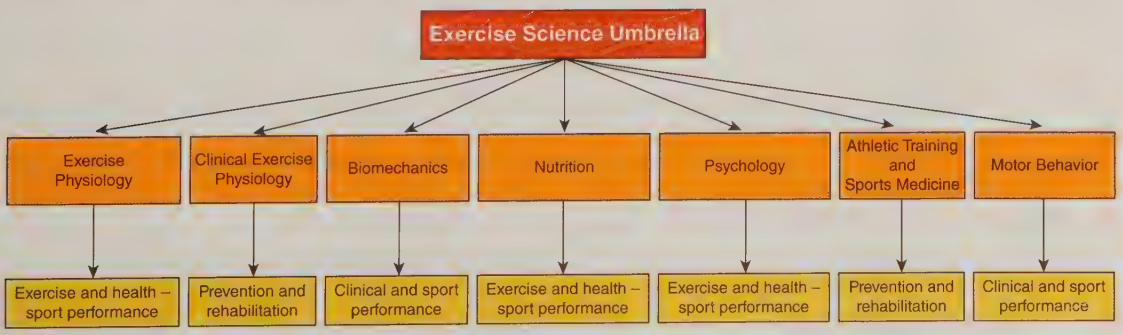

FIGURE 1.7 Relationships of the disciplines and subdisciplines of exercise science.

science umbrella. Many of the areas of study in exercise science draw on information developed by professionals in other areas, making exercise science a truly interdisciplinary field. Table 1.1 provides some examples of areas of study by exercise science students and professionals.

Exercise Science as a Field of Study

Historically, much of the study of physical activity, exercise, sport, and athletic performance originated from the academic discipline of **physical education**. Many of the early teachers and professional leaders in physical education studied and promoted the role of exercise and sport in the development of the whole person. It is clear, however, that the various areas of study in exercise science have continued to move away from physical education as the foundation academic discipline. Many of the early pioneers and leaders in the disciplines

Table 1.1 Areas of Study by Students and Professionals in Exercise Science

EXERCISE SCIENCE DISCIPLINE	AREAS OF STUDY
Exercise physiology	Physiological responses of the whole body or specific systems to physical activity, exercise, sport, and athletic competition
Clinical exercise physiology	Using movement, physical activity, and exercise in the identification, prevention, and rehabilitation of acute and chronic disease conditions
Athletic training and sports medicine	Prevention, treatment, and rehabilitation of exercise, sport, and athletic injuries
Exercise and sport nutrition	Nutritional aspects of disease prevention and health promotion and improvement of sport and athletic performance
Exercise and sport psychology	Behavioral and mental aspects of physical activity, exercise, sport, and athletic performance
Motor behavior	Development, learning, and control of body movement in healthy and diseased conditions and improvement of sport and athletic performance
Clinical and sport biomechanics	Mechanical aspects of movement in disease and injury conditions, physical activity, exercise, sport, and athletic performance

Physical education A discipline that prepares teachers to manage classroom environments, enhance student interaction and socialization, improve instruction, enhance movement skill acquisition, improve health, and increase physical activity.

and fields of study in exercise science began their careers as physical education students and teachers, but became exercise physiologists, athletic trainers, sport psychologists, or some other professional term that provided greater clarity and meaning to what they did. The areas of study in exercise science programs have moved curricular requirements away from the coursework and content knowledge of current physical education teacher licensure programs. College and university programs of study may still require physical education students to enroll in coursework in exercise physiology, biomechanics, nutrition, and motor behavior. Students of exercise science, however, are rarely required to take coursework in many of the content areas of physical education.

Over the last 60 years, professionals and leaders within exercise science and physical education have made concerted efforts to clearly define the parameters of each discipline. It is now more appropriate to define physical education as a discipline with a purpose to investigate how the teaching process can be used most effectively to acquire movement skill (38). As a discipline, physical education is primarily interested in how a body of knowledge can be developed to help individuals be better prepared as teachers, manage classroom environments, enhance student interaction and socialization, improve instruction, enhance movement skill acquisition, improve health, and increase physical activity. Conversely, exercise science is primarily interested in the study of the behavioral, functional, nutritional, physiological, and psychological functional adaptations to physical activity, exercise, sport, and athletic performance (38). As the discipline of physical education evolves to meet the expectations for the preparation of licensed teachers, there will be a further clarification of the body of knowledge required to be a successful physical education teacher. Similarly, as exercise science responds to the demands of preparing students for work in exercise and health care fields or competitive sport and athletic environments, so too will the disciplines, subdisciplines, and areas of study within exercise science continue to evolve.

Critically

Exercise science has expanded from its origins in physical education to the broad array of disciplines and subdisciplines that it encompasses today. Why do you think this trend has occurred? Why has this evolution been a good change for promoting physical activity, exercise, sport, and athletic competition?

HISTORY OF EXERCISE SCIENCE

Exploring the historic background of a specific academic discipline can provide considerable insight into the events that help shape current educational experiences and practice. This is especially true for exercise science. Answering the question "When did exercise science officially begin?" is very difficult, however, because there is no clear and definable birth of exercise science owing to its structure as a collection of disciplines and subdisciplines. Although a complete historic account of the evolution of exercise science is beyond the scope of this chapter, there are significant periods and events that deserve mentioning to allow for an understanding of how exercise science shapes our current educational programs and professional activities. Noted American College of Sports Medicine Historian Jack W. Berryman presents an excellent historic account of the important events that laid the foundation for the development of exercise science, and students are encouraged to read this account (1) and others (37,39).

Early Influences

Exercise science has evolved historically from several significant influences. Early history (starting at ~450 BC) has Greek scholars such as Hippocrates, Plato, Aristotle, and Socrates exploring physical activity in a scientific fashion and often prescribing exercise (1). Early Greek and Roman artists portrayed humans performing various feats of athletic endeavors (1). For example, one of the most well-known artistic Greek sculptures showing an athlete is the Discobolus or more commonly known as Discus Thrower (Figure 1.8). From ancient times throughout the medieval period (ca. 400 AD to 1400 AD), there was a continued interest in physical activity, exercise, and sports, primarily through studies of anatomy, physiology, and medicine (1).

During the Renaissance period (ca. fourteenth to seventeenth century), artists and scientists such as Leonardo da Vinci and Galileo Galilee had a strong analytic interest in human physical activity and health. Famous physicians such as Bombastus von Hohenheim and Thomas Linacre wrote in the areas of physiology and hygiene, respectively. In the seventeenth-century pioneers from the disciplines of biology, physics, mathematics, and chemistry were doing significant work in the area of physiology. For example, William Harvey's discovery of the circulation of the blood through arteries and veins (Figure 1.9) was instrumental in developing exciting new concepts in physiology and medicine. Harvey's most influential writings often included specific references to exercise. A significant development at this time was the use of mechanical principles to solve physiologic questions, leading to the construct of the human body as a machine. Questions about skeletal muscular contraction and pulmonary respiration interested physicians and scientists such as Robert Boyle and Robert Hooke in the 1600s. The famous English physician John Mayow wrote extensively on exercise and more specifically on muscle fibers, strength, and muscular contraction (1).

FIGURE 1.8 The Greek statue Discobolus — more commonly known as Discus Thrower. (From the Esquiline Hill; former collection Massimo-Lancellotti.)

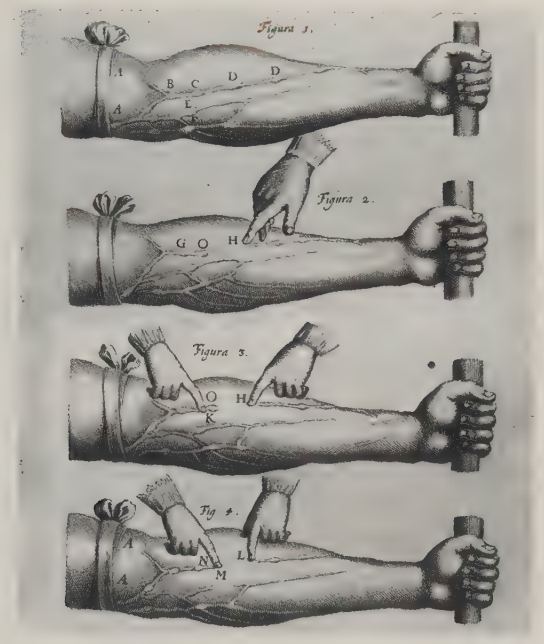

FIGURE 1.9 William Harvey described the circulation of the blood through arteries and veins. (Courtesy of the National Library of Medicine.)

The era of Enlightenment (ca. eighteenth century) saw physicians and scientists publish major works summarizing the knowledge to date on exercise, health, and life-longevity. Sir John Floyer observed and described the change in heart rate in response to moderate intensity walking, whereas London physician James Keill added to previous work on the muscular system by describing various aspects of muscle fiber size, structure, and contraction. Stephen Hales was the first to make accurate measurements of blood pressure (Figure 1.10), which ultimately contributed to Daniel Bernoulli, a Dutch mathematician, making exact calculations of the volume of blood pumped by the heart (now known as cardiac output). During this time, John Desaguliers invented the first mechanical dynamometer that was used to assess muscular force and strength. Joseph-Clement Tissot was the first to describe the effects of time, location, intensity, and duration of exercise on the physiologic processes of the body. Work by the famous French chemist Antoine-Laurent Lavoisier and French mathematician Pierre de Laplace led to the understanding of the use of oxygen to burn carbon in the body and that during physical work (*i.e.*, exercise) oxygen consumption was increased. Additional work by Lavoisier and Armand Seguin allowed for the development of the basic ideas of energy transformation and the source of heat, particularly that which occurred during exercise (1,40).

Nineteenth-Century Influences

In the early nineteenth century, the study of exercise received more attention from physicians because of its important role in the maintenance of good health and from scientists who were interested in how physical exertion and exercise affected the human body (1). During this period there was experimentation in respiratory physiology, metabolism, and nutrition, with the first experiments conducted on how dietary intake and exercise

FIGURE 1.10 Stephen Hales making the first measurement of resting blood pressure. (From the Granger Collection, New York.)

influenced the urinary system. The term physical education was introduced as a way to promote the education of individuals about their bodies, and as a result, physical exercise became more popular among the general population. The publication of several books on calisthenics and gymnastics as forms of exercise, promoted by Swedish and German physicians, occurred in the late nineteenth century (1).

In the early nineteenth century, sport and athletic competition began to be popularized in private schools and colleges and through the formation of professional teams. As a result, there was an increased interest in training the human body to improve the chance of success in sports. During the early 1800s, Sir John Sinclair of Scotland was one of the first individuals to write extensively about the role of physical training for improving performance during sport and athletic competition. Continued interest in sport and athletic performance throughout the century led to the formation of the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD), which held their first meeting in 1885 (1). AAHPERD would eventually become the Society for Health and Physical Education (SHAPE) early in the twenty-first century.

Early Twentieth-Century Influences

Exercise science continued to develop in the twentieth century, extending its roots from the discipline of physical education. Two factors played a prominent role in providing the foundation for the development of exercise science. First, colleges and universities developed specific health and physical activity–related courses in their academic curricula to promote the physical and emotional well-being of the whole person (37). The second prominent

factor was the formation of specific programs of study in colleges and universities to prepare professional physical education teachers and athletic coaches (37). Early leaders in physical education, many of whom had their academic preparations in medicine, were proponents of scientifically based, systematic programs of study. Students enrolled in physical education and coaching programs were required to take coursework in anatomy, physiology, anthropometry, and physics. Throughout the early to mid-twentieth century, the primary focus in the field of physical education was the preparation of teachers and coaches for public schools, colleges, and universities (37). In the 1930s and 1940s, the writings of two prominent scholars, Jay Bryan Nash and Charles H. McCloy, began to set the stage for a separation of exercise science from the discipline of physical education. Specifically, Nash believed that children should be educated for lifelong leisure time pursuits, whereas McCloy believed that physical education should be used to develop the human body (37).

Other principal twentieth century figures in the development of exercise science came from a variety of academic disciplines. One of the leading pioneers in the study of physical activity was Dudley Allen Sargent. Sargent received a medical degree from Yale University in 1879 and immediately became the director of the Hemenway Gymnasium at Harvard University. Sargent pioneered an all-inclusive system for individual exercise prescriptions using information from physical examinations, muscular strength assessments, and anthropometric measurements. His work in measuring strength and power and for recording and evaluating anthropometric measurements of the human body was instrumental in the development of assessment measures of human performance (40,41). One might say that Dudley Sargent was the very first personal trainer of the twentieth century.

Sargent's advances in the discipline of physical activity strongly influenced George W. Fritz, who graduated from Harvard University with a medical degree in 1891. Fritz was an enthusiastic proponent of developing theories and beliefs regarding exercise and its effect on the human organism using scientifically based physiological research (42,43). Through this work, Fritz established the Physiology Laboratory at Harvard University, which ultimately led to the establishment of the first college degree program in physical education. Graduates of this program received a Bachelor of Science degree in anatomy, physiology, and physical training. Throughout his career, Fritz explored the relationships among physical training, anatomy, and physiology, and some expert historians consider George Fritz the "father of exercise physiology" (44).

Without question, the faculty and scholars conducting research in the Harvard Fatigue Laboratory (Figure 1.11) were the key leaders in the study of physical activity and exercise in the early twentieth century. In existence from 1927 to 1947, the laboratory was home to some of the most prominent researchers at the time, including Lawrence J. Henderson and David Bruce Dill. As the first and only director of the Harvard Fatigue Laboratory, Dill was instrumental in leading laboratory research programs. Although much of the experimental research focused on exercise and environmental physiology, many of the scientists who worked in the laboratory also conducted research in related areas such as clinical

Anthropometry The study of the physical measurements and characteristics of humans and animals.

FIGURE 1.11 Exercise and environmental experiments were conducted in the Harvard Fatigue Laboratory (ca. 1945). (Photo from Baker Library Historical Collections, Harvard Business School.)

physiology, gerontology, nutrition, and physical fitness (41,43,45). The work conducted in this laboratory provided the foundation for many of the basic theories used in the study and application of exercise science today.

Perhaps, the most significant accomplishment of the Harvard Fatigue Laboratory in the evolution of exercise science was its role in the development of other prominent laboratories for the study of physical activity and exercise. For example, Steven M. Horvath, a student of Dill, started the Institute for Environmental Stress at the University of California Santa Barbara. Some of the most well-known exercise scientists were trained at the institute under Horvath, including Jack H. Wilmore and Barbara L. Drinkwater, two influential exercise science researchers and professional leaders. The Laboratory for Physiological Hygiene at the University of Minnesota, established by Ancel Keys, produced the renowned exercise scientists Ellsworth R. Buskirk and Henry Longstreet Taylor (43). These individuals and the work from their research laboratories significantly fostered our understanding of physical activity and exercise. Many other individuals also had a profound influence on the expansion of exercise science across the United States during the early to mid-twentieth century. For example, in 1923 Author Steinhaus, founded the second laboratory devoted to the study of physiology, physical activity, and exercise at the George Williams College in Chicago. Peter V. Karpovich of Springfield College is credited with introducing physiology to physical education in the United States and was instrumental in promoting the use of weightlifting for enhancing health and human performance. Another prominent exercise scientist, Thomas K. Cureton, began his professional career at Springfield College and then later moved to the University of Illinois, where he established the Physical Fitness Research Laboratory in 1941 and an adult fitness program in 1961 (43).

Late Twentieth-Century Influences

Several landmark events following World War II resulted in the significant development of exercise science. In 1953, the poor performance of U.S. children compared to European children in the standardized Kraus–Weber physical fitness tests stimulated an increased interest in fitness assessment and the promotion of physical fitness programs in schools (Figure 1.12). The formation of the American College of Sports Medicine in the mid-1950s joined physical education–based researchers with scholars from the medical community to form an

FIGURE 1.12 Administration of the Kraus–Weber physical fitness test (ca. 1954) helped promote increased interest in physical activity and exercise. (Photo by Orlando/Three Lions/Getty Images.)

organization that continues to offer significant support and promotion of exercise science and sports medicine (37). In addition, other organizations, such as the National Athletic Trainers Association (1950), the International Society of Biomechanics (1973), the National Strength and Conditioning Association (1978), and the Association for Applied Sport Psychology (1986), were created to provide support to students and professionals and to advance the mission of these professions. The decades of the 1960s and 1970s brought about the beginning of the separation of exercise science from the discipline of physical education (37) and the establishment of many of the areas of study in exercise science as stand-alone bodies of knowledge.

During the last 25 years of the twentieth century, the discipline of exercise science experienced large and profound changes. A keynote event occurred in 1970, when Kenneth H. Cooper, a physician, opened The Cooper Institute and started the Cooper Clinic. Using data from patients at the Cooper Clinic, Steven N. Blair published a landmark study in 1989 that demonstrated moderate physical activity could decrease the risk of death from all causes by 58% (46). This marked a modern shift in thought, and exercise science professionals became more actively involved in both studying and promoting the role of physical activity and exercise in health.

Additionally, during this period of time athletes at all levels became very interested in the influence of regular, systematic training on physical development and performance during sport and athletic competition. These events in the 1970s and 1980s resulted in academic departments in colleges and universities developing academic majors and minors in exercise science, as well as programs and departments of exercise science. Throughout the 1980s and 1990s, exercise science professionals continued to expand their influence in the areas of physical activity, exercise, sport, and athletic performance.

Twenty-First-Century Influences

During the first part of the twenty-first century, exercise science scholars and professionals have continued to clarify the role of physical activity and exercise in the promotion of

health and the reduction of disease conditions. Over the last 20 years we have come to better understand the role of physical activity and inactivity in the development of lifestyle diseases. This knowledge has led to the further refinement of how much physical activity is sufficient to reduce the risk of cardiovascular disease (9), cancer (47), and diabetes (48).

During the last 20 years, the areas of sport and athletic performance have seen considerable attention focused on overall athlete health, and, more specifically, the impact of head trauma on health and longevity (49,50). Chronic traumatic encephalopathy (CTE) is a brain condition associated with repeated blows to the head. CTE is associated with the development of dementia and problems with thinking and memory, personality changes, and behavioral changes including aggression and depression (51). As a result of this knowledge, new and innovative assessment techniques are being developed so exercise science professionals can identify individuals who are impacted by repeated head trauma and these individuals can be treated appropriately. Of critical importance has been the development of concussion protocols (52) and alternate training methods and practice protocols in an effort to reduce the number of exposures to head trauma by athletes (53).

There continues to be an expansion of health promotion and physical activity and exercise programs by professional organizations and governmental agencies, and the participation of exercise science professionals in the success of those programs will be instrumental. For example, multidisciplinary approaches to solving individual and population-based health-related problems such as the obesity epidemic and promoting **health equity** are being accomplished by using the knowledge and skills of exercise physiologists, nutritionists, biomechanists, exercise behaviorists, and health care specialists working together.

Think Critically

In what specific ways has exercise science contributed to a broader understanding of how physical activity and exercise influence physical fitness and health?

In what specific ways has exercise science contributed to a broader understanding of how exercise and training influence sport and athletic performance?

In an effort to gain a greater understanding of how the disciplines and subdisciplines of exercise science have evolved, each chapter of this textbook will further examine the historic development of those areas identified in Table 1.1. This information is intended to provide you with a better understanding of how past events have affected the present and will shape the future of the exercise science disciplines.

EXERCISE SCIENCE AND THE AMERICAN COLLEGE OF SPORTS MEDICINE

There is probably no organization that has been more effective in developing and promoting exercise science than the American College of Sports Medicine (ACSM). One only has to attend a national conference of the ACSM and observe the broad array of exercise science

Health equity Absence of preventable or unfair differences among groups of people defined socially, economically, demographically, geographically, or by other methods of stratification.

and sports medicine topics presented by professionals from around the world to truly appreciate the vast impact of the ACSM. Although many of the disciplines and subdisciplines under the exercise science umbrella have their own professional organizations, none is so broad reaching in exercise science as the ACSM. Several significant events are worth discussing so that students of exercise science may have an understanding of how physical activity, exercise, sport, and athletic performance have been shaped by the ACSM since its founding. For a more detailed study of the early history and influence of the ACSM, students are directed to an additional reading (54).

Early Development of the ACSM

The first meeting of the organization that eventually became the ACSM occurred in 1954 as part of the afternoon program of the American Association for Health, Physical Education, and Recreation national meeting. The initial name chosen by the founding members "Federation of Sports Medicine" was changed to the ACSM in 1955 when the organization was officially incorporated. There were 11 professionals from the disciplines of physical education, physiology, and medicine who were instrumental in the establishment of the ACSM (54).

The ACSM developed as a result of increased interest of both the general public and professionals in health and exercise (54). Two other factors also played a prominent role in the evolution of ACSM: the interest by the U.S. military in physical fitness, physical training, and rehabilitation of military personnel in the post–World War II period and the growth of sports medicine in the international arena prompted by the Federation Internationale Medico Sportive (FIMS). At the time, FIMS was a world leader in the areas of sport and athletics. College and university team physicians and athletic trainers also contributed significantly to the formal development of the ACSM. The influence of the above factors catalyzed the founding members of the ACSM to define sports medicine as a "unique blend of physical education, medicine, and physiology" (54).

From its establishment, the ACSM and its members provided significant public outreach and worked to influence public policy. For example, in 1955, members of the ACSM provided professional guidance to U.S. President Dwight D. Eisenhower's National Conference on Physical Fitness. This commitment to public involvement has continued throughout ACSM's history and currently includes programs such as ACSM's annual International Health and Fitness Summit and the Advanced Team Physician Program, which provide opportunities for practicing professionals to receive the most current information in all areas of exercise science and sports medicine. Publications such as the *ACSM's Health and Fitness Journal*, *Fit Society Page*, and the *Sports Medicine Bulletin* allow ACSM professionals to provide meaningful health and fitness information to the general public.

The membership of the ACSM has always been actively involved in performing research and scholarship. ACSM members have provided valuable insight into the prevention and management of lifestyle-related diseases such as coronary artery disease, hypertension, diabetes, and cancer, and the rehabilitation of stroke patients and injured athletes. Much of this information is broadly available in the peer-reviewed journal *Medicine and Science in*

Peer-reviewed The formal evaluation of a professional colleague's work by experts in the field.

Sports and Exercise, published regularly by ACSM since 1969. Early in its development as an organization, the ACSM maintained an emphasis on and commitment to sound quality science and research. This commitment remains strong as the ACSM funds promising young scholars with support from the ACSM Foundation (54).

ACSM has been considered the world's leader in exercise science and sports medicine information since 1974, when it published its first **position stand** "Prevention of thermal injuries during distance running" (55). Throughout its history, ACSM has continued to publish position stands and opinion papers that have helped shape health, physical activity, exercise, sport, and athletic performance in the United States and around the world. Table 1.2 provides a list of the current position stands published by the ACSM (54). Copies of these position stands can be found on the ACSM Web page at www.acsm.org.

Table 1.2 Position Stands from the American College of Sports Medicine

POSITION STAND	YEAR PUBLISHED
ADA/ACSM joint position statement: exercise and Type 2 diabetes (2)	2000
AHA/ACSM joint position statement: automated external defibrillators in health/fitness facilities (61)	2002
AHA/ACSM joint position statement: recommendations for cardiovascular screening, staffing, and emergency policies at health/fitness facilities (62)	1998
Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults (63)	2009
Exercise and acute cardiovascular events: placing the risks into perspective (64)	2007
Exercise and fluid replacement (65)	2007
Exercise and hypertension (66)	2004
Exercise and physical activity for older adults (4)	2009
Exercise for patients with coronary artery disease (67)	1994
Exertional heat illness during training and competition (68)	2007
Nutrition and athletic performance (69)	2016
Physical activity and bone health (6)	2004
Physical activity, fitness, cognitive function, and academic achievement in children (70)	2016

Position stand An evidence-based statement on a topic of relevance to those in the fields of exercise science and sports medicine created by experts in the topic.

Table 1.2 Position Stands from the American College of Sports Medicine (*continued*)

POSITION STAND	YEAR PUBLISHED
Prevention of cold injuries during exercise (71)	2006
Progression models in resistance training for healthy adults (72)	2009
Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise (5)	2011
The female athlete triad (73)	2007
The use of anabolic-androgenic steroids in sports (74)	1987
The use of blood doping as an ergogenic aid (75)	1996
Weight loss in wrestlers (76)	1996

The initial edition of the highly acclaimed book *Guidelines for Graded Exercise Testing and Prescription* first became available in 1974. This science and research-based book continues to be a valuable source of information for exercise science and sports medicine professionals. During the 1970s, the ACSM first awarded professional certification to individuals who completed training as exercise program directors and exercise specialists. The ACSM continues to furnish practical information through continuing education activities, periodical and nonperiodical publications, certification opportunities, and annual meetings (54).

During the early 1980s, interest in exercise and sports medicine in the United States greatly increased, and ACSM responded strongly to this interest. In 1983, a little less than 30 years after its founding, the ACSM was well over 10,000 professional and student members. During the 1980s, the professional certification program in the ACSM continued to grow and included two categories: rehabilitation and prevention. Individuals who demonstrated competencies in the rehabilitation category could become certified as program directors, exercise specialists, and exercise test technologists. By demonstrating competences in the prevention category, members became certified as a health/fitness director, health/fitness instructor, and exercise leader/aerobics (54). These programs continue today with opportunities for certification in health and fitness (ACSM Certified Personal Trainer®, ACSM Certified Exercise Physiologist, and ACSM Certified Group Exercise Instructor℠), clinical (ACSM Certified Clinical Exercise Physiologist®), and Specialty credentials (Exercise is Medicine® Credential, ACSM/ACS Certified Cancer Exercise Trainer, ACSM/NCHPAD Certified Inclusive Fitness Trainer, and ACSM/NPAS Physical Activity in Public Health Specialist). During the late 1980s, the ACSM established formal relationships with the President's Council on Physical Fitness and Sports and the Office of Disease Prevention and Health Promotion within the U.S. Department of Health and Human Services (54).

Throughout the 1990s, ACSM continued to promote its research and outreach activities by making *Medicine and Science in Sports and Exercise* a monthly publication, offering the Team Physician Course, and disseminating exercise science and sports medicine position stands to ACSM members and the general public (54). These position stands continue to shape public policy and practice in the areas of health, physical activity, exercise, sport, and

athletic competition. In 1994, ACSM provided consultation to the U.S. Centers for Disease Control and Prevention (CDC) and the President's Council on Physical Fitness and Sport as new recommendations for appropriate levels of physical activity were being developed. The resulting report from the U.S. Surgeon General provided guidelines for the amount of physical activity required to obtain significant health benefits and reduce the risk of developing chronic poor health conditions such as heart disease, hypertension, diabetes, and osteoporosis (56). Furthering its commitment to physical activity, the ACSM joined with several other professional organizations and government agencies in 1995 to form the National Coalition for Promoting Physical Activity (NCPPA) (54). The mission of the NCPPA is to unite the strengths of public, private, and industry organization efforts into collaborative partnerships that inspire and empower all Americans to lead more physically active lifestyles (www.ncppa.org). The ACSM has continued to develop and present key exercise science publications. A current listing of prominent ACSM publications is shown in Table 1.3.

ACSM has partnered with other professional organizations to promote improved safety and care for competitive athletes. In 1994 the ACSM, working with the American College of Cardiology, developed recommendations for determining eligibility for competition in

Table 1.3 Key Exercise Science-Related Publications from the American College of Sports Medicine

ACSM's Behavioral Aspects of Physical Activity and Exercise

ACSM's Body Composition Assessment

ACSM's Certification Review, Sixth Edition

ACSM's Clinical Exercise Physiology

ACSM's Complete Guide to Fitness & Health, Second Edition

ACSM's Exercise for Older Adults

ACSM's Exercise is Medicine

ACSM's Exercise Management for Persons with Chronic Diseases and Disabilities, Fourth Edition

ACSM's Exercise Testing and Prescription

ACSM's Fitness Assessment Manual, Sixth Edition

ACSM's Foundations of Strength Training and Conditioning, Second Edition

ACSM's Guide to Exercise and Cancer Survivorship

ACSM's Guidelines for Exercise Testing and Prescription, Eleventh Edition

ACSM's Health/Fitness Facility Standards and Guidelines, Fifth Edition

ACSM's Metabolic Calculations Handbook

ACSM's Nutrition for Exercise Science

Table 1.3 Key Exercise Science-Related Publications from the American College of Sports Medicine (*continued*)

ACSM's Research Methods
ACSM's Resources for the Exercise Physiologist, Third Edition
ACSM's Resources for the Group Exercise Instructor
ACSM/NCHPAD Resources for the Inclusive Fitness Trainer
ACSM's Resources for the Personal Trainer, Sixth Edition
ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription, Seventh Edition
ACSM's Sports Medicine: A Comprehensive Review

athletes with cardiovascular abnormalities (57). In 1996, the ACSM partnered with the American Medical Society for Sports Medicine (AMSSM) and the American Orthopaedic Society for Sports Medicine (AOSSM) to present the first Advanced Team Physician Course. ACSM remains committed to educating team physicians through publications such as *ACSM's Primary Care Sports Medicine*, *ACSM's Exercise is Medicine®*, and *ACSM's Sports Medicine: A Comprehensive Review*. The Team Physician Consensus statement, a collective effort by members of ACSM, AOSSM, AMSSM, and the American Academy of Orthopaedic Surgeons, was first published in 2000. This statement provided physicians, school administrators, team owners, the general public, and individuals who are responsible for making decisions regarding the medical care of athletes and teams with guidelines for choosing a qualified team physician and an outline of the duties expected of a team physician (58).

Recent Role of the ACSM

The ACSM continues to increase its influence by working to shape public policy, supporting research, expanding educational opportunities for exercise science and sports medicine professionals, and disseminating knowledge to the general public. The ACSM has made commitments to influence world health through its roles with the Active Aging Partnership/National Blueprint, Musculoskeletal Partnership, and Exercise is Medicine® initiative. At the 52nd Annual Meeting in 2005, the ACSM and the President's Council on Physical Fitness and Sports announced a collaboration to benefit public health by jointly promoting physical activity, fitness, and sports. In 2006, the Federation of American Societies for Experimental Biology (FASEB) accepted ACSM into the Federation, further solidifying ACSM as a leader in the study of health, physical activity, exercise, sport, and athletic performance.

In 2007, ACSM developed the American Fitness Index™ (AFI), a signature program created in partnership with the WellPoint Foundation. The purpose was to provide an evidence-based and science-based measurement of the state of health and fitness at the community level throughout the United States. The AFI is designed to improve the health, fitness, and quality of life of Americans by promoting physical activity, using three key components: collecting, analyzing, and reporting on data related to healthy lifestyles and physical activity; serving as a resource for communities; and assisting communities inter-

on physical activity/healthy lifestyle initiatives. Additional information about the AFI can be found at www.americanfitnessindex.org.

Additionally, in 2007, the ACSM partnered with the American Medical Association (AMA) to co-launch the Exercise is Medicine® (EIM) initiative. EIM is a United States-based health initiative coordinated by the ACSM. The original purpose of EIM was to make the scientifically proven benefits of physical activity a standard component of the U.S. health care system by having health care providers promote physical activity as an important component of their patient's health. More information about EIM can be found at www.exerciseismedicine.org.

Throughout the last decade, ACSM has been at the forefront of providing leadership and creating opportunities for advancement in exercise science. The Integrative Physiology of Exercise Conference (2010), the Basic Science World Congress (2014), launching of the *Translational Journal of ACSM* (2016), and the Exercise and Cancer Prevention and Control Roundtable (2018) are just a few examples of impactful initiatives promoted and sponsored by ACSM. The Datalys Center was established in 2018 and is a collaborative venture among Biocrossroads, the NCAA, and the ACSM. This consortium conducts research and provides surveillance expertise to support the sports injury data needs of researchers, sports governing organizations, and the sports medicine community. Additionally, leadership positions have been added to the ACSM Board of Trustees in the areas of Health Equity, Diversity, and Inclusion, as well as an International Trustee position to better serve the needs of all individuals interested in the disciplines and subdisciplines of exercise science.

The ACSM continues to build upon its rich history established and fostered by its world leaders in exercise science and sports medicine as it adheres to its mission:

> To promote and integrate scientific research, education, and practical applications of sports medicine and exercise science to maintain and enhance physical performance, fitness, health, and quality of life.

Think Critically

In what significant ways has the ACSM contributed to the development of exercise science and the related fields of study?

The fulfillment of this mission will allow the ACSM to remain instrumental in helping exercise science professionals to create and disseminate valuable information and shape policy affecting health, physical activity, exercise, sport, and athletic performance.

ACADEMIC PREPARATION IN EXERCISE SCIENCE

As presented in this chapter and others throughout the book, you will see that exercise science professionals come from a variety of educational backgrounds and disciplines. Appropriate academic preparation is critical to developing and preparing for a successful career as an exercise science or sports medicine professional. Chapter 12 will focus on professional careers you can enter into as an exercise science major. Undergraduate students in a program of study in exercise science must pay particular attention to meeting certain prerequisites and degree requirements, especially in a program, major, or profession that requires the successful completion of a licensure or certification examination upon graduation with

FIGURE 1.13 Athletic trainers work with individuals injured during physical activity, exercise, sport, or athletic competitions. (Shutterstock.)

an undergraduate or graduate degree. For example, exercise science students interested in becoming certified athletic trainers (Figure 1.13) or registered dietitians (Figure 1.14) must complete the program requirements and graduate from an accredited program in athletic training or dietetics. Exercise science can also be a valuable and effective program of study for those who want to enter into postbaccalaureate study in the medical or **allied health care** fields or for completing further graduate education.

Undergraduate Coursework

Undergraduate exercise science programs and their degree majors are typically broad based and include coursework in anatomy, biology, biochemistry, chemistry, health, human development, mathematics, physics, physiology, psychology, and statistics. Information from

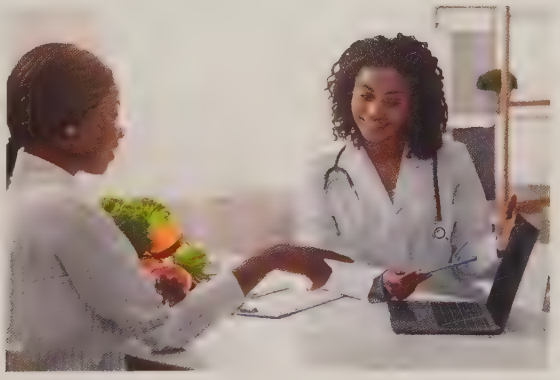

FIGURE 1.14 Registered dietitians counsel patients about proper nutritional intake. (Shutterstock.)

Allied health care The professional field that works to deliver patient care services for the identification, prevention, and treatment of diseases, disabilities, and disorders.

these courses helps provide a solid foundation for understanding how and why humans move. Advanced coursework provides enhanced knowledge in particular areas of study. For example, depending on the major or minor area of study, students can enroll in coursework in exercise physiology, fitness programming in health and disease, motor development, control, and behavior, nutrition, structural and functional biomechanics, exercise testing and prescription, laboratory techniques, strength and flexibility training, exercise and sport psychology, research methods, evaluation and assessment of athletic injuries, and rehabilitation modalities, among others. Additional involvement in research or scholarly projects, co-ops, internships, and clinical activities, can provide much needed preparation and experience. The foundational and advanced coursework and practical experiences are designed to provide basic and applied knowledge to prepare exercise science students for the next phase of their professional career including certification or licensure examinations, employment, graduate study, and training in professional schools. Students interested in careers in medicine or another allied health profession must also meet the major requirements for entry into that chosen field.

As you begin your course of study, it is very important that you understand the requirements of the career path you wish to take after graduation. Chapter 12 provides valuable information about professional employment and career opportunities. It is important to make sure your coursework at the undergraduate level provides you with the knowledge, skills, and abilities necessary for your chosen career path. Although the information contained in the following sections provides a general overview of the requirements for continued preparation, it is essential that you speak with a career advisor or counselor at your college or university. That individual will guide you to the most appropriate coursework and experiences for achieving your career goals. Table 1.4 provides key foundational recommendations for continued educational and professional development.

Preparation for Careers in Health Care

It is becoming increasingly common for students to major in an exercise science program as an undergraduate student and then complete postbaccalaureate work in a health care

Table 1.4 Foundational Recommendations for Continued Educational and Professional Development

CONTINUED PROFESSIONAL DEVELOPMENT	RECOMMENDATION
Graduate study	Complete the degree and prerequisite requirements for the intended graduate program of study; engage in undergraduate research if possible
Professional schools	Meet the degree requirements and prerequisites for the professional program of study; complete clinical observations and internships
Certification/licensure	Meet all eligibility requirements established by the professional certifying or licensing agency
Employment	Gain appropriate internship, clinical, or field experience in the potential field of professional employment

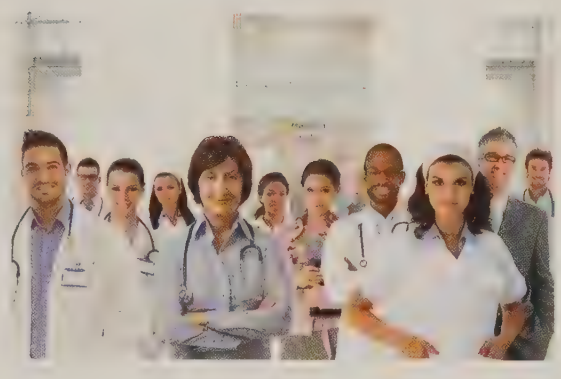

FIGURE 1.15 Allied health care professionals frequently come from undergraduate exercise science programs. (Shutterstock.)

field (Figure 1.15). An undergraduate degree in exercise science allows the flexibility of course selection to fulfill the requirements necessary for entry into medical, chiropractic, or dental school, a physician assistant program, and physical or occupation therapy programs. Obtaining a degree in exercise science will provide additional benefits in preparation for advanced health care education. Coursework in physical activity and exercise prescription for healthy and diseased populations, exercise testing and evaluation, nutrition for health and athletic performance, and exercise and sport psychology can provide valuable knowledge and experiences for advanced study in health care. The following sections serve as a general overview for those students intending to pursue postbaccalaureate study in a health care field or graduate school. If you have decided to pursue a career in medicine or allied health care, you are strongly encouraged to obtain information from those schools you may consider attending so that you have all necessary information regarding the schools' specific entrance requirements. You are strongly encouraged to contact your college or university premedical or health care advisor to assist you in developing your undergraduate coursework and program of study in exercise science. Additionally, almost all health care programs use an online application service, so it is important to be familiar with the requirements of the specific platform.

Preparation for Medical School

There are approximately 160 **allopathic** (MD) and 40 **osteopathic** (DO) accredited medical schools and programs in the United States and Canada. Generally, the minimum academic requirements for acceptance into these schools include one academic year of coursework in

Allopathic medicine A branch of medicine that uses medications, radiation, or surgery to treat or suppress symptoms or the ill effects of disease.

Osteopathic medicine A branch of medicine that treats diseases using a whole person approach to treatment including medications, surgery, spinal manipulation, or massage therapy, as part of the treatment.

biology, general chemistry, organic chemistry, English, and physics. Additional coursework in biochemistry, cell and molecular biology, mammalian physiology, and psychology also provides valuable preparation for medical school. Some medical schools also require a year of college mathematics, including coursework in statistics. Becoming proficient in a foreign language may also be helpful.

To enter medical school following graduation from college, you must complete all premedical requirements prior to your expected matriculation into medical school. You should take the Medical College Aptitude Test (MCAT) at least 3 to 6 months before submitting your application. Medical school admissions committees evaluate candidates largely, although not completely, on objective criteria. Therefore, a high overall grade point average, a high science course grade point average, and competitive MCAT scores are important. Other factors considered by admissions committees include well-developed interpersonal skills, evidence of leadership potential, supportive letters of recommendation, prior work or volunteer experience in a health care facility, and performance in a personal interview. Additional information for preparing for a career in medicine may be obtained from the following organizations: Association of American Medical Colleges (www.aamc.org) and American Association of Colleges of Osteopathic Medicine (www.aacom.org).

Preparation for Dental School

There are approximately 75 accredited schools or programs of dentistry in the United States and Canada. Preparation for entry into a dental program should include knowledge of the basic biological and physical sciences and proficiency in verbal communication. Minimum academic course requirements for acceptance generally include one academic year of introductory biology, inorganic chemistry, organic chemistry, English, mathematics, and physics (with each of the science courses having a laboratory component). Additional coursework in comparative anatomy, developmental biology, biochemistry, cell and molecular biology, genetics, histology, human physiology, and microbiology may also provide valuable preparation for entering a program in dentistry. Owing to the visual, mechanical, and personal nature of the activities you will participate in as a dentist, it may be advantageous to also consider taking courses in art, business, interpersonal communication, and behavioral psychology.

The Dental Admissions Test (DAT) is required by dental schools and programs and should be taken at least 3 to 6 months before submitting your application to dental schools. Your application materials should be completed and submitted approximately 1 year prior to your anticipated matriculation date. Dentistry programs consider a variety of factors in selecting students, including a high overall grade point average, good DAT scores, strong letters of recommendation (including those from a practicing dentist), and a significant number of hours of observation with a practicing dentist. Other important factors considered by admissions committees include a strong interest in dentistry, awareness of the terminology used in dentistry, demonstrated good manual dexterity, and performance during a personal interview. Additional information for preparing for a career in dentistry may be obtained from the following associations: American Dental Association (www.ada.org) and the American Academy of Pediatric Dentistry (www.aapd.org).

Preparation for Chiropractic School

There are approximately 20 fully accredited schools and programs of **chiropractic medicine** in the United States and Canada. All individuals practicing chiropractic medicine must pass the State Board of Health Examination in the state in which they intend to establish professional practice. Although all states sanction the practice of chiropractic medicine, most of the state boards of health also require that an applicant for a licensing examination be a graduate of an accredited college or university program. The primary focus of chiropractic medicine is spine manipulation, for which X-rays may be used as a diagnostic tool. Doctors of Chiropractic medicine also use nutrition and patient counseling as part of the complete health care practice. Neither drug treatment nor surgery may be performed by a Doctor of Chiropractic medicine. Most chiropractic programs require 4 years of study, although some schools may offer a 3-year program.

Schools of chiropractic medicine vary in the number of credit hours and specific courses required for admission. Students interested in applying to a program of study in chiropractic medicine should check on the specific entrance requirements. In general, a minimum of 2 years of college coursework must be completed prior to entering a chiropractic school, and several states require chiropractic physicians to have a baccalaureate degree in addition to the chiropractic degree to be licensed to practice chiropractic medicine.

Students are encouraged to check the Association of Chiropractic Colleges directory or individual school admissions requirements. The following list of minimal entrance requirements should serve as a general guide, although specific entrance requirements may vary slightly at each school. Students are required to have 1 year of the following courses: biological sciences, general chemistry, organic chemistry, and physics (with each of the courses having a laboratory component). Students should also have 1 year of English or communications, one semester of psychology, and coursework in the social sciences or humanities. Generally, multiple letters of recommendation are required with at least one from a practicing chiropractic physician. Applicants are generally evaluated on the basis of their undergraduate grade point average and coursework, the MCAT (if required by the school), clinical exposure and experience, personal attributes, involvement in extracurricular activities, service to others, and a personal interview with the admissions committee. Additional information for preparing for a career in chiropractic medicine may be obtained from the Association of Chiropractic Colleges (www.chirocolleges.org).

Preparation for Podiatric Medical School

There are approximately 10 accredited schools of **podiatric medicine** in the United States and Canada. Generally, the minimum academic requirements for acceptance into these schools include one academic year of coursework in biology, general chemistry, organic chemistry, English, communications, and physics. Podiatric medical schools may also have

Chiropractic medicine A branch of medicine that uses manual therapy and manipulations of the body to treat or suppress symptoms or the ill effects of injuries or disorders of the body.

Podiatric medicine A branch of medicine that diagnoses and treats conditions affecting the foot, ankle, and related structures of the leg.

specific requirements, so make sure to check the application requirements for all schools you may consider applying to.

To enter podiatric medical school following graduation from college, you should complete all premedical requirements at least 1 year prior to your expected matriculation into school. You should take the MCAT at least 3 to 6 months before submitting your application. Podiatric medical school admissions committees evaluate candidates on grade point average, science course grade point average, and MCAT scores. Other factors considered by admissions committees include well-developed interpersonal skills, evidence of leadership potential, letters of recommendation, and performance in a personal interview. Additional information for preparing for a career in podiatric medicine may be obtained from the American Association of Colleges of Podiatric Medicine (www.aacpm.org).

Preparation for Physician Assistant Programs

There are approximately 250 fully accredited physician assistant programs in the United States and Canada. The typical physician assistant program is 24 to 32 months in duration and requires at least 4 years of college and some health care experience prior to admission. Applicants to physician assistant programs must complete approximately 2 years of college courses in basic science and behavioral science as prerequisites to physician assistant training. This is similar to the premedical requirements for medical students. Students interested in physician assistant programs should take coursework in the basic sciences, including anatomy, biochemistry, behavioral sciences, clinical laboratory sciences, microbiology, medical ethics, pathophysiology, pharmacology, physical diagnosis, and physiology. Additional coursework in communications and psychology is encouraged. Preference in admission is usually given to candidates who have prior experience in a health care setting. The hallmark of physician assistant education is the clinical training in a variety of inpatient and outpatient settings, including family medicine, internal medicine, obstetrics and gynecology, pediatrics, general surgery, emergency medicine, and psychiatry (Figure 1.16).

The independent Accreditation Review Commission on Education for the Physician Assistant, Inc. accredits all physician assistant programs. Only graduates of accredited programs are eligible to sit for the Physician Assistant National Certifying Exam administered by the independent National Commission on Certification of Physician Assistants and developed by the National Board of Medical Examiners. All 50 states and the District of Columbia have enacted laws or regulations authorizing physician assistant practice and authorize physician assistants to prescribe controlled medicines. Once a physician assistant is certified, she or he must complete 100 hours of continuing medical education every 2 years

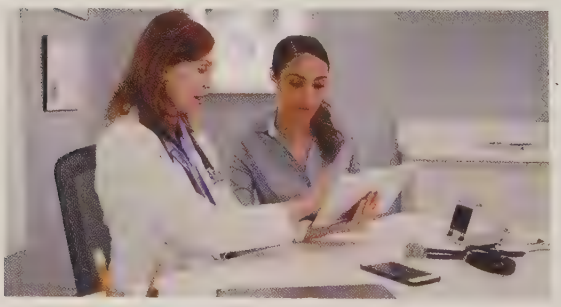

FIGURE 1.16 Physician assistants work in a variety of inpatient and outpatient setting. (Shutterstock.)

and take a recertification exam every 10 years to keep her/his certification current. Additional information for preparing for a career as a physician assistant may be obtained from the following associations: the American Academy of Physician Assistants (www.aapa.org) and Physician Assistant Education Association at (www.paeaonline.org).

Preparation for Physical and Occupational Therapy

There are approximately 500 fully accredited physical therapy (PT) and physical therapy assistant (PTA) programs and approximately 300 fully accredited occupational therapy (OT) and occupational therapy assistant (OTA) programs in the United States. Undergraduate degree programs in exercise science provide excellent preparation for graduate study in physical and occupational therapy because many exercise science programs offer the required coursework for direct entry into a physical or occupational therapy program (Figures 1.17 and 1.18).

The American Physical Therapy Association (APTA) has mandated that all PT programs offer a doctoral degree in physical therapy (DPT) to earn or retain certification. Therefore, students interested in PT must earn a doctoral degree from an accredited DPT program before taking the licensure examination. Each school has its own prerequisite courses for admission into a program, and therefore it is strongly recommended that you identify the programs you may wish to attend and verify the list of requirements for admission. In general, most DPT programs require the following courses for admission: one academic year

FIGURE 1.17 Physical therapists provide rehabilitation in an assortment of professional practices. (Shutterstock.)

FIGURE 1.18 Occupational therapists provide functional rehabilitation to improve patients' daily routines and lives. (Shutterstock.)

of biology, chemistry, and physics (with a laboratory component for each). Additionally, most programs require at least one course in each of the following: English composition, exercise physiology, human anatomy, human physiology, biomechanics, general psychology, developmental psychology, and statistics. Additional coursework in biochemistry, organic chemistry, medical ethics, philosophy, and speech composition may also be valuable.

The American Occupational Therapy Association (AOTA) oversees the OT profession and provides support for graduate programs in OT. Students interested in OT must earn a Master's or doctoral degree from an accredited OT program and then pass a licensure examination in order to practice as an OT. Each school has its own prerequisite courses for admission into a program, and therefore it is strongly recommended that you identify the programs you may wish to attend and verify the list of requirements for admission. In general, most OT programs require the following courses for admission: human anatomy and physiology, neuroanatomy or neuropsychology or behavioral neuroscience, kinesiology, psychopathology, lifespan development, statistics, and at least one course in psychology, sociology, anthropology, public health, or related field. Additional coursework in biochemistry, organic chemistry, medical ethics, philosophy, and speech composition may also be valuable.

The majority of schools offering the Master of science in occupational therapy (MSOT), or doctorate of occupational therapy (OTD), and DPT programs either require or recommend the Graduate Record Examination (GRE) as part of the admission materials, whereas other schools may require the Allied Health Professions Aptitude Test. Physical and occupational therapy programs require that candidates have volunteered in PT or OT clinics. Many PT and OT admissions committees look for evidence of exposure to the types of patients with whom you will eventually be working and for experience in a variety of clinical settings. The number of required volunteer hours varies by school and program and must be certified by a health care professional. A general recommendation is that you complete at least 100 hours of volunteer service. Other important factors considered by admissions committees include well-developed interpersonal skills and performance during a personal interview. Additional information for preparing for a career in physical or occupational therapy may be obtained from the following associations: APTA (www.APTA.org) and the AOTA (www.aota.org).

Preparation for Graduate School

Obtaining an undergraduate degree in exercise science provides excellent preparation for continuing education in graduate school. A graduate degree is typically earned at the Master's or doctorate degree level after completing the Bachelor's degree. Graduate degree programs are different from Bachelor's degree programs in many ways, the most distinguishing being graduate degree programs do not have general education requirements and instead focus on gaining more skill and content knowledge at a higher level. Additionally, many graduate programs have extensive research components in the form of advanced methodology, statistics, and independent research.

Each of the areas of study in exercise science may be offered as graduate programs in many colleges and universities. Most graduate programs require 1 to 2 years of study for a Master's degree and 3 to 5 years of study for a doctoral degree. Many graduate degree programs require a research project, Master's thesis, or doctoral dissertation as the culminating experience, while others require an internship. Graduate programs have specific requirements for entry into the program and completion of the degree that are often unique

Table 1.5 Guidelines for Identifying and Selecting a Program for Graduate Study

Explore areas of interest to you, being sure to review the research interests and teaching expertise of the faculty in the graduate program
Identify an individual who holds a position you envision yourself moving into, talk to that person about their educational journey
Use various graduate school search engines to gain knowledge about different programs of study
Use an admissions counselor, academic advisor, and mentor to help you learn more about which graduate programs might be the best fit for you
Communicate with faculty from your undergraduate program about which graduate programs are appropriate for your interests

to the discipline and the particular college or university. Obtaining a graduate degree will generally result in greater marketability, a higher income, greater job responsibility, and more professional opportunities. In addition, many professional employment opportunities require an advanced degree beyond a Bachelor's degree. Furthermore, an exercise science degree can provide solid preparation for graduate degrees in areas such as athletic training, public health, epidemiology, physiology, biochemistry, psychology, and biomedical engineering.

Additional information about specific graduate programs can be obtained by visiting the home page of the college or university that you are interested in attending. Table 1.5 provides some guidance for identifying and selecting an appropriate program to continue your graduate education.

Think Critically

How does your choice of undergraduate coursework in exercise science best prepare you for a career in the professional fields of medicine and allied health?

Interview

Jack W. Berryman, PhD, FACSM

Professor Emeritus of Medical History at the University of Washington School of Medicine, Seattle, Washington. Jack is also ACSM Historian Emeritus and past Chair of ACSM's Office of Museum, History, and Archives

Brief Introduction – I began my college education as a Health and Physical Education major at Lock Haven University in Pennsylvania. In the early 1970s, I completed two Master's degrees at the University of Massachusetts, Amherst: one in Exercise Science and the other in History. During this time, I became involved in the early stages of the exercise science and sport studies movement. I completed a PhD at the University

of Maryland in Physical Education and History, and I joined the University of Washington faculty in 1975. In 1992, I was voted a fellow in the American Academy of Kinesiology and Physical Education and in 1994, was named ACSM's official historian. I became a fellow in ACSM in 2001. Two of my books of special interest are *Sport and Exercise Science: Essays in the History of Sports Medicine* (1992) and *Out of Many, One: A History of the American College of Sports Medicine* (1995). I have been honored as ACSM's D. B. Dill Historical Lecturer an unprecedented two times, in 1994 and 2004, and received ACSM's Citation Award in 2017.

Q: What is ACSM's importance in the development of exercise science?

Because of ACSM's unique multidisciplinary membership that included physicians, physical educators, exercise scientists, and many other professions directly related to the health benefits of exercise, the organization became a leader in the field by the late 1950s. ACSM's annual meetings, along with its significant journals and books, as well as position stands and scientific roundtables, put ACSM in the forefront of health promotion and exercise science very quickly. With a strong scientific and clinical base, the ACSM has continued to be the most respected authority in the field of exercise science. The ACSM has played a leadership role in the National Coalition for Promoting Physical Activity (1995) and in the writing of *Physical Activity and Health: A Report of the Surgeon General* (1996). The College has been a dominant force in the institutionalization of exercise in the prevention, diagnosis, and treatment of cardiac and other degenerative diseases such as diabetes, osteoporosis, and obesity.

Q: What is ACSM's importance in the development of sport and athletic performance?

Although ACSM's early emphasis was on health and fitness, the ACSM began to move more in the direction of clinical sports medicine and athletic training in the 1970s. Through annual meetings and publications, those with clinical sports medicine expertise were gradually attracted to the ACSM. By the 1980s, ACSM had as professional members some of the leading sport team physicians and athletic trainers in the world. Research and publications began to focus on the prevention and treatment of sports injuries, peak athletic performance, the role of the team physician, and other important aspects of athleticism, such as the female athlete triad and proper hydration. The ACSM also offers a series of team physician courses, which are important in disseminating information to practicing physicians. In the early 2000s, ACSM began publishing *Current Sports Medicine Reports*, a clinical review journal. More recently, ACSM has been the driving force behind the movement to identify and treat concussions in a timely manner.

Q: How will ACSM contribute as a world leader in exercise science into the twenty-first century?

ACSM has in its membership the leaders in exercise science and sports medicine worldwide. This highly scientific international membership continues to position the ACSM at the forefront of any major development in the field. The ACSM also has a very proactive and highly talented professional staff at its headquarters in Indianapolis who work tirelessly to further ACSM's goals. Publications, annual meetings, special symposia, certifications, and position stands, among numerous other projects, have a constant impact on the field. Because of its stature, the ACSM has had a significant impact on policy decisions and continues to be the most dynamic force to identify exercise deficiency as a serious public health issue. The ACSM believes that exercise is, in fact, good medicine and will continue to convince federal, state, and local officials that physical activity is the key to good health and the prevention of disease through its worldwide Exercise is Medicine campaign.

Interview

Scott K. Powers, EdD, PhD, FACSM

UAA Endowed Professor and Distinguished Professor, Department of Applied Physiology & Kinesiology at the University of Florida. Scott is a past Vice President of the ACSM

Brief Introduction – I earned my BS degree in Physical Education from Carson Newman University, and after completing a Master's degree at the University of Georgia, I then earned a doctoral degree in Exercise Science (with an emphasis in Exercise Physiology) from the University of Tennessee. I desired additional training in Basic Science and Biochemistry, and subsequently completed a PhD in Physiology and Cell Biology from Louisiana State University.

Q: What are your most significant career experiences?

I began my professional career as a faculty member in the Department of Kinesiology at Louisiana State University, and I am currently a professor within the Department of Applied Physiology and Kinesiology at the University of Florida. Citing my research and teaching accomplishments, the University of Florida honored me with an endowed professorship in 2004 followed by the title of "distinguished professor" in 2005. Throughout my career, I have been active in both the American Physiological Society and the ACSM, having served both organizations via committee memberships and as an elected officer.

Q: Why did you choose to become an exercise science professional?

My personal interest in exercise physiology began during my undergraduate studies at Carson Newman University. As a distance runner on our collegiate track team, I became fascinated with the physiology of human performance and began to read all of the exercise physiology texts available at the time. I quickly realized that knowledge in exercise physiology was limited in many areas and, hence, a need for additional research existed. Fueled by natural curiosity, I decided to pursue a graduate degree in exercise physiology to learn more about this exciting field. My experience in graduate school served to motivate me to expand my knowledge about exercise physiology and to dedicate my career to research and teaching in exercise physiology.

Q: What are your top two or three professional accomplishments?

From a research perspective, my primary achievements have come in three different areas of inquiry. First, during the 1980s, my laboratory investigated the factors that control breathing and regulate pulmonary gas exchange during exercise. An important finding related to this work was that pulmonary gas exchange limits maximal oxygen uptake in many elite endurance athletes. This novel observation revealed that the lung and not the cardiovascular system limits maximal oxygen uptake in this population of elite athletes.

In 1990, my research focus shifted toward two new areas of investigation: (a) exercise-induced cardioprotection; and (b) disuse muscle atrophy. By studying how exercise changes the heart, my research group has made significant contributions to our understanding of

how and why regular bouts of endurance exercise protect the heart during a heart attack. This form of cardiac safeguard is termed exercise-induced cardioprotection and provides direct evidence about the importance of exercise. In this regard, our work demonstrates that as few as 5 continuous days of endurance exercise results in cardioprotection. However, this exercise-induced protection is lost quickly (*i.e.*, within 18 days) after the cessation of exercise. Moreover, our research has revealed some of the key cellular mechanisms that are responsible for exercise-induced cardioprotection. This work is important and has led to the development of several pharmacological approaches to protect the heart against cellular injury during an ischemia-reperfusion insult (*i.e.*, heart attack).

Finally, my research team has also made some important discoveries regarding the mechanisms responsible for disuse muscle atrophy (*i.e.*, muscle loss owing to inactivity resulting from prolonged bed rest, limb immobilization, etc.). By investigating the mechanisms responsible for this type of muscle wasting, our research team hopes to develop countermeasures to prevent this type of muscle atrophy and prevent or retard this cause of muscle atrophy.

Q: What advice would you have for a student exploring a career in exercise science?

Successful individuals in any profession share many of the same traits. A key trait of all successful people is that they are passionate about what they do. Therefore, my advice to students exploring career options is to find your passion in life. In short, what career would make you happy so that you enjoy going to work each morning? Is it possible to enjoy going to work? YES! A job is only work if you do not like it. So, find your passion and you will never "work" a day in your life! Although locating your passion in life is the first important step in developing your career, it is critical that you receive state-of-the-art training to help you achieve your professional goals. Therefore, before choosing a major, do your homework and research the best courses that will provide you with the science background required to achieve your professional goals. Notably, choosing the "correct" faculty mentors to guide you during your graduate school education and through your postdoctoral training is vital to ensure that you receive the cutting-edge instruction that will launch your career on the right track.

SUMMARY

- Exercise science refers to the application of science to the study of movement in health, physical activity, exercise, sport, and athletic performance.
- Exercise science has evolved from the work of scholars and professionals from a variety of disciplines, subdisciplines, and specialty areas.
- Much of the educational coursework provided in a curriculum of study is valuable preparation for professional employment or continued study in graduate or professional school.
- Teachers, coaches, exercise specialists, health care providers, scholars, and researchers use the knowledge gained from exercise science in both basic and applied contexts.
- Exercise science is truly interdisciplinary with individuals from a wide array of backgrounds working together to provide the most relevant information and answer important questions related to individual health, exercise, medicine, public health, sport, and athletic competition.

FOR REVIEW

1. What is the difference between morbidity and mortality?
2. What disciplines, subdisciplines, and specialty areas constitute exercise science?

3. Describe the foundational characteristics of an academic discipline and explain how exercise science meets those characteristics?
4. What are the similarities and unique differences between physical activity, exercise, sport, and athletic competition?
5. What historical factors have contributed to the creation of exercise science as an overarching field of study?
6. In what significant ways did the Harvard Fatigue Laboratory contribute to the development of exercise science?
7. What are the primary ways the ACSM disseminates information to the professional membership and general population?
8. Why must exercise science students devote close attention to required coursework if planning on obtaining certification or licensure after graduation?
9. What are the primary requirements for entry into a professional career in a health care field after graduation?

Project-Based Learning

1. Identify the top ten graduate or professional programs you may be interested in attending after completing your undergraduate degree, review the admission criteria, and create a systematic process for selecting the program for which you want to enroll after your undergraduate education is complete.
2. Choose an ACSM position stand from Table 1.2, identify the top five take-home messages that you would share with a fellow student, and present those messages in either a written report or an oral presentation.

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