

# CHAPTER 1

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## INTRODUCTION, SUMMARY, AND CHAPTER CONCLUSIONS

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# CHAPTER 1

## INTRODUCTION, SUMMARY, AND CHAPTER CONCLUSIONS

### Introduction

This is the first Surgeon General's report to address physical activity and health. The main message of this report is that Americans can substantially improve their health and quality of life by including moderate amounts of physical activity in their daily lives. Health benefits from physical activity are thus achievable for most Americans, including those who may dislike vigorous exercise and those who may have been previously discouraged by the difficulty of adhering to a program of vigorous exercise. For those who are already achieving regular moderate amounts of activity, additional benefits can be gained by further increases in activity level.

This report grew out of an emerging consensus among epidemiologists, experts in exercise science, and health professionals that physical activity need not be of vigorous intensity for it to improve health. Moreover, health benefits appear to be proportional to amount of activity; thus, every increase in activity adds some benefit. Emphasizing the amount rather than the intensity of physical activity offers more options for people to select from in incorporating physical activity into their daily lives. Thus, a moderate amount of activity can be obtained in a 30-minute brisk walk, 30 minutes of lawn mowing or raking leaves, a 15-minute run, or 45 minutes of playing volleyball, and these activities can be varied from day to day. It is hoped that this different emphasis on moderate amounts of activity, and the flexibility to vary activities according to personal preference and life circumstances, will encourage more people to make physical activity a regular and sustainable part of their lives.

The information in this report summarizes a diverse literature from the fields of epidemiology, exercise physiology, medicine, and the behavioral sciences. The report highlights what is known about

physical activity and health, as well as what is being learned about promoting physical activity among adults and young people.

### Development of the Report

In July 1994, the Office of the Surgeon General authorized the Centers for Disease Control and Prevention (CDC) to serve as lead agency for preparing the first Surgeon General's report on physical activity and health. The CDC was joined in this effort by the President's Council on Physical Fitness and Sports (PCPFS) as a collaborative partner representing the Office of the Surgeon General. Because of the wide interest in the health effects of physical activity, the report was planned collaboratively with representatives from the Office of the Surgeon General, the Office of Public Health and Science (Office of the Secretary), the Office of Disease Prevention (National Institutes of Health [NIH]), and the following institutes from the NIH: the National Heart, Lung, and Blood Institute; the National Institute of Child Health and Human Development; the National Institute of Diabetes and Digestive and Kidney Diseases; and the National Institute of Arthritis and Musculoskeletal and Skin Diseases. CDC's nonfederal partners—including the American Alliance for Health, Physical Education, Recreation, and Dance; the American College of Sports Medicine; and the American Heart Association—provided consultation throughout the development process.

The major purpose of this report is to summarize the existing literature on the role of physical activity in preventing disease and on the status of interventions to increase physical activity. Any report on a topic this broad must restrict its scope to keep its message clear. This report focuses on disease prevention and therefore does not include the considerable body of evidence on the benefits of physical activity for treatment or

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rehabilitation after disease has developed. This report concentrates on endurance-type physical activity (activity involving repeated use of large muscles, such as in walking or bicycling) because the health benefits of this type of activity have been extensively studied. The importance of resistance exercise (to increase muscle strength, such as by lifting weights) is increasingly being recognized as a means to preserve and enhance muscular strength and endurance and to prevent falls and improve mobility in the elderly. Some promising findings on resistance exercise are presented here, but a comprehensive review of resistance training is beyond the scope of this report. In addition, a review of the special concerns regarding physical activity for pregnant women and for people with disabilities is not undertaken here, although these important topics deserve more research and attention.

Finally, physical activity is only one of many everyday behaviors that affect health. In particular, nutritional habits are linked to some of the same aspects of health as physical activity, and the two may be related lifestyle characteristics. This report deals solely with physical activity; a Surgeon General's Report on Nutrition and Health was published in 1988.

Chapters 2 through 6 of this report address distinct areas of the current understanding of physical activity and health. Chapter 2 offers a historical perspective: after outlining the history of belief and knowledge about physical activity and health, the chapter reviews the evolution and content of physical activity recommendations. Chapter 3 describes the physiologic responses to physical activity—both the immediate effects of a single episode of activity and the long-term adaptations to a regular pattern of activity. The evidence that physical activity reduces the risk of cardiovascular and other diseases is presented in Chapter 4. Data on patterns and trends of physical activity in the U.S. population are the focus of Chapter 5. Lastly, Chapter 6 examines efforts to increase physical activity and reviews ideas currently being proposed for policy and environmental initiatives.

### Major Conclusions

1. People of all ages, both male and female, benefit from regular physical activity.
2. Significant health benefits can be obtained by including a moderate amount of physical activity (e.g., 30 minutes of brisk walking or raking leaves, 15 minutes of running, or 45 minutes of playing volleyball) on most, if not all, days of the week. Through a modest increase in daily activity, most Americans can improve their health and quality of life.
3. Additional health benefits can be gained through greater amounts of physical activity. People who can maintain a regular regimen of activity that is of longer duration or of more vigorous intensity are likely to derive greater benefit.
4. Physical activity reduces the risk of premature mortality in general, and of coronary heart disease, hypertension, colon cancer, and diabetes mellitus in particular. Physical activity also improves mental health and is important for the health of muscles, bones, and joints.
5. More than 60 percent of American adults are not regularly physically active. In fact, 25 percent of all adults are not active at all.
6. Nearly half of American youths 12–21 years of age are not vigorously active on a regular basis. Moreover, physical activity declines dramatically during adolescence.
7. Daily enrollment in physical education classes has declined among high school students from 42 percent in 1991 to 25 percent in 1995.
8. Research on understanding and promoting physical activity is at an early stage, but some interventions to promote physical activity through schools, worksites, and health care settings have been evaluated and found to be successful.

### Summary

The benefits of physical activity have been extolled throughout western history, but it was not until the second half of this century that scientific evidence supporting these beliefs began to accumulate. By the 1970s, enough information was available about the beneficial effects of vigorous exercise on cardiorespiratory fitness that the American College of Sports Medicine (ACSM), the American Heart Association (AHA), and other national organizations began issuing physical activity recommendations to the public. These recommendations generally focused on cardiorespiratory endurance and specified sustained periods of vigorous physical activity involving large muscle groups and lasting at least 20 minutes on 3 or

more days per week. As understanding of the benefits of less vigorous activity grew, recommendations followed suit. During the past few years, the ACSM, the CDC, the AHA, the PCPFS, and the NIH have all recommended regular, moderate-intensity physical activity as an option for those who get little or no exercise. The *Healthy People 2000* goals for the nation's health have recognized the importance of physical activity and have included physical activity goals. The 1995 *Dietary Guidelines for Americans*, the basis of the federal government's nutrition-related programs, included physical activity guidance to maintain and improve weight—30 minutes or more of moderate-intensity physical activity on all, or most, days of the week.

Underpinning such recommendations is a growing understanding of how physical activity affects physiologic function. The body responds to physical activity in ways that have important positive effects on musculoskeletal, cardiovascular, respiratory, and endocrine systems. These changes are consistent with a number of health benefits, including a reduced risk of premature mortality and reduced risks of coronary heart disease, hypertension, colon cancer, and diabetes mellitus. Regular participation in physical activity also appears to reduce depression and anxiety, improve mood, and enhance ability to perform daily tasks throughout the life span.

The risks associated with physical activity must also be considered. The most common health problems that have been associated with physical activity are musculoskeletal injuries, which can occur with excessive amounts of activity or with suddenly beginning an activity for which the body is not conditioned. Much more serious associated health problems (i.e., myocardial infarction, sudden death) are also much rarer, occurring primarily among sedentary people with advanced atherosclerotic disease who engage in strenuous activity to which they are unaccustomed. Sedentary people, especially those with preexisting health conditions, who wish to increase their physical activity should therefore gradually build up to the desired level of activity. Even among people who are regularly active, the risk of myocardial infarction or sudden death is somewhat increased during physical exertion, but their overall risk of these outcomes is lower than that among people who are sedentary.

Research on physical activity continues to evolve. This report includes both well-established findings and newer research results that await replication and amplification. Interest has been developing in ways to differentiate between the various characteristics of physical activity that improve health. It remains to be determined how the interrelated characteristics of amount, intensity, duration, frequency, type, and pattern of physical activity are related to specific health or disease outcomes.

Attention has been drawn recently to findings from three studies showing that cardiorespiratory fitness gains are similar when physical activity occurs in several short sessions (e.g., 10 minutes) as when the same total amount and intensity of activity occurs in one longer session (e.g., 30 minutes). Although, strictly speaking, the health benefits of such intermittent activity have not yet been demonstrated, it is reasonable to expect them to be similar to those of continuous activity. Moreover, for people who are unable to set aside 30 minutes for physical activity, shorter episodes are clearly better than none. Indeed, one study has shown greater adherence to a walking program among those walking several times per day than among those walking once per day, when the total amount of walking time was kept the same. Accumulating physical activity over the course of the day has been included in recent recommendations from the CDC and ACSM, as well as from the NIH Consensus Development Conference on Physical Activity and Cardiovascular Health.

Despite common knowledge that exercise is healthful, more than 60 percent of American adults are not regularly active, and 25 percent of the adult population are not active at all. Moreover, although many people have enthusiastically embarked on vigorous exercise programs at one time or another, most do not sustain their participation. Clearly, the processes of developing and maintaining healthier habits are as important to study as the health effects of these habits.

The effort to understand how to promote more active lifestyles is of great importance to the health of this nation. Although the study of physical activity determinants and interventions is at an early stage, effective programs to increase physical activity have been carried out in a variety of settings, such as schools, physicians' offices, and worksites. Determining the most effective and cost-effective intervention

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approaches is a challenge for the future. Fortunately, the United States has skilled leadership and institutions to support efforts to encourage and assist Americans to become more physically active. Schools, community agencies, parks, recreational facilities, and health clubs are available in most communities and can be more effectively used in these efforts.

School-based interventions for youth are particularly promising, not only for their potential scope—almost all young people between the ages of 6 and 16 years attend school—but also for their potential impact. Nearly half of young people 12–21 years of age are not vigorously active; moreover, physical activity sharply declines during adolescence. Childhood and adolescence may thus be pivotal times for preventing sedentary behavior among adults by maintaining the habit of physical activity throughout the school years. School-based interventions have been shown to be successful in increasing physical activity levels. With evidence that success in this arena is possible, every effort should be made to encourage schools to require daily physical education in each grade and to promote physical activities that can be enjoyed throughout life.

Outside the school, physical activity programs and initiatives face the challenge of a highly technological society that makes it increasingly convenient to remain sedentary and that discourages physical activity in both obvious and subtle ways. To increase physical activity in the general population, it may be necessary to go beyond traditional efforts. This report highlights some concepts from community initiatives that are being implemented around the country. It is hoped that these examples will spark new public policies and programs in other places as well. Special efforts will also be required to meet the needs of special populations, such as people with disabilities, racial and ethnic minorities, people with low income, and the elderly. Much more information about these important groups will be necessary to develop a truly comprehensive national initiative for better health through physical activity. Challenges for the future include identifying key determinants of physically active lifestyles among the diverse populations that characterize the United States (including special populations, women, and young people) and using this information to design and disseminate effective programs.

## Chapter Conclusions

### Chapter 2: Historical Background and Evolution of Physical Activity Recommendations

1. Physical activity for better health and well-being has been an important theme throughout much of western history.
2. Public health recommendations have evolved from emphasizing vigorous activity for cardiorespiratory fitness to including the option of moderate levels of activity for numerous health benefits.
3. Recommendations from experts agree that for better health, physical activity should be performed regularly. The most recent recommendations advise people of all ages to include a minimum of 30 minutes of physical activity of moderate intensity (such as brisk walking) on most, if not all, days of the week. It is also acknowledged that for most people, greater health benefits can be obtained by engaging in physical activity of more vigorous intensity or of longer duration.
4. Experts advise previously sedentary people embarking on a physical activity program to start with short durations of moderate-intensity activity and gradually increase the duration or intensity until the goal is reached.
5. Experts advise consulting with a physician before beginning a new physical activity program for people with chronic diseases, such as cardiovascular disease and diabetes mellitus, or for those who are at high risk for these diseases. Experts also advise men over age 40 and women over age 50 to consult a physician before they begin a vigorous activity program.
6. Recent recommendations from experts also suggest that cardiorespiratory endurance activity should be supplemented with strength-developing exercises at least twice per week for adults, in order to improve musculoskeletal health, maintain independence in performing the activities of daily life, and reduce the risk of falling.

## Introduction, Summary, and Chapter Conclusions

### Chapter 3: Physiologic Responses and Long-Term Adaptations to Exercise

1. Physical activity has numerous beneficial physiologic effects. Most widely appreciated are its effects on the cardiovascular and musculoskeletal systems, but benefits on the functioning of metabolic, endocrine, and immune systems are also considerable.
2. Many of the beneficial effects of exercise training—from both endurance and resistance activities—diminish within 2 weeks if physical activity is substantially reduced, and effects disappear within 2 to 8 months if physical activity is not resumed.
3. People of all ages, both male and female, undergo beneficial physiologic adaptations to physical activity.

### Chapter 4: The Effects of Physical Activity on Health and Disease

#### *Overall Mortality*

1. Higher levels of regular physical activity are associated with lower mortality rates for both older and younger adults.
2. Even those who are moderately active on a regular basis have lower mortality rates than those who are least active.

#### *Cardiovascular Diseases*

1. Regular physical activity or cardiorespiratory fitness decreases the risk of cardiovascular disease mortality in general and of coronary heart disease mortality in particular. Existing data are not conclusive regarding a relationship between physical activity and stroke.
2. The level of decreased risk of coronary heart disease attributable to regular physical activity is similar to that of other lifestyle factors, such as keeping free from cigarette smoking.
3. Regular physical activity prevents or delays the development of high blood pressure, and exercise reduces blood pressure in people with hypertension.

#### *Cancer*

1. Regular physical activity is associated with a decreased risk of colon cancer.

2. There is no association between physical activity and rectal cancer. Data are too sparse to draw conclusions regarding a relationship between physical activity and endometrial, ovarian, or testicular cancers.
3. Despite numerous studies on the subject, existing data are inconsistent regarding an association between physical activity and breast or prostate cancers.

#### *Non-Insulin-Dependent Diabetes Mellitus*

- 1.) Regular physical activity lowers the risk of developing non-insulin-dependent diabetes mellitus.

#### *Osteoarthritis*

1. Regular physical activity is necessary for maintaining normal muscle strength, joint structure, and joint function. In the range recommended for health, physical activity is not associated with joint damage or development of osteoarthritis and may be beneficial for many people with arthritis.
2. Competitive athletics may be associated with the development of osteoarthritis later in life, but sports-related injuries are the likely cause.

#### *Osteoporosis*

1. Weight-bearing physical activity is essential for normal skeletal development during childhood and adolescence and for achieving and maintaining peak bone mass in young adults.
2. It is unclear whether resistance- or endurance-type physical activity can reduce the accelerated rate of bone loss in postmenopausal women in the absence of estrogen replacement therapy.

#### *Falling*

1. There is promising evidence that strength training and other forms of exercise in older adults preserve the ability to maintain independent living status and reduce the risk of falling.

#### *Obesity*

1. Low levels of activity, resulting in fewer kilocalories used than consumed, contribute to the high prevalence of obesity in the United States.
2. Physical activity may favorably affect body fat distribution.

## Physical Activity and Health

### **Mental Health**

1. Physical activity appears to relieve symptoms of depression and anxiety and improve mood.
2. Regular physical activity may reduce the risk of developing depression, although further research is needed on this topic.

### **Health-Related Quality of Life**

1. Physical activity appears to improve health-related quality of life by enhancing psychological well-being and by improving physical functioning in persons compromised by poor health.

### **Adverse Effects**

1. Most musculoskeletal injuries related to physical activity are believed to be preventable by gradually working up to a desired level of activity and by avoiding excessive amounts of activity.
2. Serious cardiovascular events can occur with physical exertion, but the net effect of regular physical activity is a lower risk of mortality from cardiovascular disease.

## Chapter 5: Patterns and Trends in Physical Activity

### **Adults**

1. Approximately 15 percent of U.S. adults engage regularly (3 times a week for at least 20 minutes) in vigorous physical activity during leisure time.
2. Approximately 22 percent of adults engage regularly (5 times a week for at least 30 minutes) in sustained physical activity of any intensity during leisure time.
3. About 25 percent of adults report no physical activity at all in their leisure time.
4. Physical inactivity is more prevalent among women than men, among blacks and Hispanics than whites, among older than younger adults, and among the less affluent than the more affluent.
5. The most popular leisure-time physical activities among adults are walking and gardening or yard work.

### **Adolescents and Young Adults**

1. Only about one-half of U.S. young people (ages 12–21 years) regularly participate in vigorous physical activity. One-fourth report no vigorous physical activity.

2. Approximately one-fourth of young people walk or bicycle (i.e., engage in light to moderate activity) nearly every day.
3. About 14 percent of young people report no recent vigorous or light-to-moderate physical activity. This indicator of inactivity is higher among females than males and among black females than white females.
4. Males are more likely than females to participate in vigorous physical activity, strengthening activities, and walking or bicycling.
5. Participation in all types of physical activity declines strikingly as age or grade in school increases.
6. Among high school students, enrollment in physical education remained unchanged during the first half of the 1990s. However, daily attendance in physical education declined from approximately 42 percent to 25 percent.
7. The percentage of high school students who were enrolled in physical education and who reported being physically active for at least 20 minutes in physical education classes declined from approximately 81 percent to 70 percent during the first half of this decade.
8. Only 19 percent of all high school students report being physically active for 20 minutes or more in daily physical education classes.

## Chapter 6: Understanding and Promoting Physical Activity

1. Consistent influences on physical activity patterns among adults and young people include confidence in one's ability to engage in regular physical activity (e.g., self-efficacy), enjoyment of physical activity, support from others, positive beliefs concerning the benefits of physical activity, and lack of perceived barriers to being physically active.
2. For adults, some interventions have been successful in increasing physical activity in communities, worksites, and health care settings, and at home.
3. Interventions targeting physical education in elementary school can substantially increase the amount of time students spend being physically active in physical education class.

## CHAPTER 2

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# HISTORICAL BACKGROUND, TERMINOLOGY, EVOLUTION OF RECOMMENDATIONS, AND MEASUREMENT

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## CHAPTER 2

# HISTORICAL BACKGROUND, TERMINOLOGY, EVOLUTION OF RECOMMENDATIONS, AND MEASUREMENT

### Introduction

*The exercise boom is not just a fad; it is a return to 'natural' activity—the kind for which our bodies are engineered and which facilitates the proper function of our biochemistry and physiology. Viewed through the perspective of evolutionary time, sedentary existence, possible for great numbers of people only during the last century, represents a transient, unnatural aberration. (Eaton, Shostak, Konner 1988, p. 168)*

This chapter examines the historical development of physical activity promotion as a means to improve health among entire populations. The chapter focuses on Western (i.e., Greco-Roman) history, because of the near-linear development of physical activity promotion across those times and cultures leading to current American attitudes and guidelines regarding physical activity. These guidelines are discussed in detail in the last half of the chapter. To flesh out this narrow focus on Western traditions, as well as to provide a background for the promotional emphasis of the chapter, this chapter begins by briefly outlining both anthropological and historical evidence of the central, “natural” role of physical activity in prehistoric cultures. Mention is also made of the historical prominence of physical activity in non-Greco-Roman cultures, including those of China, India, Africa, and precolonial America.

Archaeologists working in conjunction with medical anthropologists have established that our ancestors up through the beginning of the Industrial Revolution incorporated strenuous physical activity as a normal part of their daily lives—and not only for the daily, subsistence requirements of their “work” lives. Investigations of preindustrial societies still

intact today confirm that physical capability was not just a grim necessity for success at gathering food and providing shelter and safety (Eaton, Shostak, Konner 1988). Physical activity was enjoyed throughout everyday prehistoric life, as an integral component of religious, social, and cultural expression. Food supplies for the most part were plentiful, allowing ample time for both rest and recreational physical endeavors.

Eaton, Shostak, and Konner (1988) describe a “Paleolithic rhythm” (p. 32) observed among contemporary hunters and gatherers that seems to mirror the medical recommendations for physical activity in this report. This natural cycle of regularly intermittent activity was likely the norm for most of human existence. Sustenance preoccupations typically were broken into 1- or 2-day periods of intense and strenuous exertion, followed by 1- or 2-day periods of rest and celebration. During these rest days, however, less intense but still strenuous exertion accompanied 6- to 20-mile round-trip visits to other villages to see relatives and friends and to trade with other clans or communities. There or at home, dancing and cultural play took place.

As the neolithic Agricultural Revolution allowed more people to live in larger group settings and cities, and as the specialization of occupations reduced the amount and intensity of work-related physical activities, various healers and philosophers began to stress that long life and health depended on preventing illnesses through proper diet, nutrition, and physical activity. Such broad prescriptions for health, including exercise recommendations, long predate the increasingly specific guidelines of classical Greek philosophy and medicine, which are the predominant historical focus of this chapter.

## Physical Activity and Health

In ancient China as early as 3000 to 1000 B.C., the classic *Yellow Emperor's Book of Internal Medicine* (Huang Ti 1949) first described the principle that human harmony with the world was the key to prevention and that prevention was the key to long life (Shampo and Kyle 1989). These principles grew into concepts that became central to the 6th century Chinese philosophy Taoism, where longevity through simple living attained the status of a philosophy that has guided Chinese culture through the present day. tai chi chuan, an exercise system that teaches graceful movements, began as early as 200 B.C. with Hua T'o and has recently been shown to decrease the incidence of falls in elderly Americans (Huard and Wong 1968; see Chapter 4).

In India, too, proper diet and physical activity were known to be essential principles of daily living. The *Ajur Veda*, a collection of health and medical concepts verbally transmitted as early as 3000 B.C., developed into Yoga, a philosophy that included a comprehensively elaborated series of stretching and flexibility postures. The principles were first codified in 600 B.C. in the *Upanishads* and later in the *Yoga Sutras* by Patanjali sometime between 200 B.C. and 200 A.D. Yoga philosophies also asserted that physical suppleness, proper breathing, and diet were essential to control the mind and emotions and were prerequisites for religious experience. In both India and China during this period, the linking of exercise and health may have led to the development of a medical subspecialty that today would find its equivalent in sports medicine (Snook 1984).

Though less directly concerned with physical health than with social and religious attainment, physical activity played a key role in other ancient non-Greco-Roman cultures. In Africa, systems of flexibility, agility, and endurance training not only represented the essence of martial arts capability but also served as an integral component of religious ritual and daily life. The Samburu and the Masai of Kenya still feature running as a virtue of the greatest prowess, linked to manhood and social stature.

Similarly, in American Indian cultures, running was a prominent feature of all major aspects of life (Nabokov 1981). Long before the Europeans invaded, Indians ran to communicate, to fight, and to

hunt. Running was also a means for diverse American Indian cultures to enact their myths and thereby construct a tangible link between themselves and both the physical and metaphysical worlds. Among the Indian peoples Nabokov cites are the Mesquakie of Iowa, the Chemeheuvi of California, the Inca of Peru, the Zuni and other Pueblo peoples of the American Southwest, and the Iroquois of the American East, who also developed the precursor of modern-day lacrosse. Even today, the Tarahumarah of northern Mexico play a version of kickball that involves entire villages for days at a time (Nabokov 1981; Eaton, Shostak, Konner 1988).

### Western Historical Perspective

Besides affecting the practice of preventive hygiene (as is discussed throughout this section), the ancient Greek ideals of exercise and health have influenced the attitudes of modern western culture toward physical activity. The Greeks viewed great athletic achievement as representing both spiritual and physical strength rivaling that of the gods (Jaeger 1965). In the classical-era Olympic Games, the Greeks viewed the winners as men who had the character and physical prowess to accomplish feats beyond the capability of most mortals. Although participants in the modern Olympic Games no longer compete with the gods, today's athletes inspire others to be physically active and to realize their potential—an inspiration as important for modern peoples as it was for the ancient Greeks.

### Early Promotion of Physical Activity for Health

Throughout much of recorded western history, philosophers, scientists, physicians, and educators have promoted the idea that being physically active contributes to better health, improved physical functioning, and increased longevity. Although some of these claims were based on personal opinions or clinical judgment, others were the result of systematic observation.

Among the ancient Greeks, the recognition that proper amounts of physical activity are necessary for healthy living dates back to at least the 5th century B.C. (Berryman 1992). The lessons found in the

## Historical Background, Terminology, Evolution of Recommendations, and Measurement

“laws of health” taught during the ancient period sound familiar to us today: to breathe fresh air, eat proper foods, drink the right beverages, take plenty of exercise, get the proper amount of sleep, and include our emotions when analyzing our overall well-being.

Western historians agree that the close connection between exercise and medicine dates back to three Greek physicians—Herodicus (ca. 480 B.C.), Hippocrates (ca. 460–ca. 377 B.C.), and Galen (A.D. 129–ca. 199). The first to study therapeutic gymnastics—or gymnastic medicine, as it was often called—was the Greek physician and former exercise instructor, Herodicus. His dual expertise united the gymnastic with the medical art, thereby preparing the way for subsequent Greek study of the health benefits of physical activity.

Although Hippocrates is generally known as the father of preventive medicine, most historians credit Herodicus as the influence behind Hippocrates’ interest in the hygienic uses of exercise and diet (Cyriax 1914; Precupe 1952; Licht 1984; Olivova 1985). *Regimen*, the longer of Hippocrates’ two works dealing with hygiene, was probably written sometime around 400 B.C. In Book 1, he writes:

*Eating alone will not keep a man well; he must also take exercise. For food and exercise, while possessing opposite qualities, yet work together to produce health. For it is the nature of exercise to use up material, but of food and drink to make good deficiencies. And it is necessary, as it appears, to discern the power of various exercises, both natural exercises and artificial, to know which of them tends to increase flesh and which to lessen it; and not only this, but also to proportion exercise to bulk of food, to the constitution of the patient, to the age of the individual, to the season of the year, to the changes in the winds, to the situation of the region in which the patient resides, and to the constitution of the year. (1953 reprint, p. 229)*

Hippocrates was a major influence on the career of Claudius Galenus, or Galen, the Greek physician who wrote numerous works of great importance to medical history during the second century. Of these works, his book entitled *On Hygiene* contains the most information on the healthfulness of exercise.

Whether by sailing, riding on horseback, or driving, or via cradles, swings, and arms, everyone, even infants, Galen said, needed exercise (Green 1951 trans., p. 25). He further stated:

*The uses of exercise, I think, are twofold, one for the evacuation of the excrements, the other for the production of good condition of the firm parts of the body. For since vigorous motion is exercise, it must needs be that only these three things result from it in the exercising body—hardness of the organs from mutual attrition, increase of the intrinsic warmth, and accelerated movement of respiration. These are followed by all the other individual benefits which accrue to the body from exercise; from hardness of the organs, both insensitivity and strength for function; from warmth, both strong attraction for things to be eliminated, readier metabolism, and better nutrition and diffusion of all substances, whereby it results that solids are softened, liquids diluted, and ducts dilated. And from the vigorous movement of respiration the ducts must be purged and the excrements evacuated. (p. 54)*

The classical notion that one could improve one’s health through one’s own actions—for example, through eating right and getting enough sleep and exercise—proved to be a powerful influence on medical theory as it developed over the centuries. Classical medicine had made it clear to physicians and the lay public alike that responsibility for disease and health was not the province of the gods. Each person, either independently or in counsel with his or her physician, had a moral duty to attain and preserve health. When the Middle Ages gave way to the Renaissance, with its individualistic perspective and its recovery of classical humanistic influences, this notion of personal responsibility acquired even greater emphasis. Early vestiges of a “self-help” movement arose in western Europe in the 16th century. As that century progressed, “laws of bodily health were expressed as value prescriptions” (Burns 1976, p. 208).

More specifically, “orthodox Greek hygiene,” as Smith (1985, p. 257) called it, flourished as part of the revival of Galenic medicine as early as the 13th century. The leading medical schools of the

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world—Italy's Salerno, Padua, and Bologna—taught hygiene to their students as part of general instruction in the theory and practice of medicine. The works of Hippocrates and Galen dominated a system whereby “the ultimate goal was to be able to practise medicine in the manner of the ancient physicians” (Bylebyl 1979, p. 341).

Hippocrates' *Regimen* also became important during the Renaissance in a literature that Gruman (1961) identified as “prolongevity hygiene” and defined as “the attempt to attain a markedly increased longevity by means of reforms in one's way of life” (p. 221). Central to this literature was the belief that persons who decided to live a temperate life, especially by reforming habits of diet and exercise, could significantly extend their longevity. Beginning with the writings of Luigi Cornaro in 1558, the classic Greek preventive hygiene tradition achieved increasing attention from those wishing to live longer and healthier lives.

Christobal Mendez, who received his medical training at the University of Salamanca, was the author of the first printed book devoted to exercise, *Book of Bodily Exercise* (1553). His novel and comprehensive ideas preceded developments in exercise physiology and sports medicine often thought to be unique to the early 20th century. The book consists of four treatises that cover such topics as the effects of exercise on the body and on the mind. Mendez believed, as the humoral theorists did, that the physician had to clear away excess moisture in the body. Then, after explaining the ill effects of vomiting, bloodletting, purging, sweating, and urination, he noted that “exercise was invented and used to clean the body when it was too full of harmful things. It cleans without any of the above-mentioned inconvenience and is accompanied by pleasure and joy (as we will say). If we use exercise under the conditions which we will describe, it deserves lofty praise as a blessed medicine that must be kept in high esteem” (1960 reprint, p. 22).

In 1569, Hieronymus Mercurialis' *The Art of Gymnastics Among the Ancients* was published in Venice. Mercurialis quoted Galen extensively and provided a descriptive compilation of ancient material from nearly 200 works by Greek and Roman authors. In general, Mercurialis established the following exercise principles: people who are ill should

not be given exercise that might aggravate existing conditions; special exercises should be prescribed on an individual basis for convalescent, weak, and older patients; people who lead sedentary lives need exercise urgently; each exercise should preserve the existing healthy state; exercise should not disturb the harmony among the principal humors; exercise should be suited to each part of the body; and all healthy people should exercise regularly.

Although Galenism and the humoral theory of medicine were displaced by new ideas, particularly through the study of anatomy and physiology, the Greek principles of hygiene and regimen continued to flourish in 18th century Europe. For some 18th century physicians, such nonintervention tactics were practical alternatives to traditional medical therapies that employed bloodletting and heavy dosing with compounds of mercury and drugs—“heroic” medicine (Warner 1986), in which the “cure” was often worse than the disease.

George Cheyne's *An Essay of Health and Long Life* was published in London in 1724. By 1745, it had gone through 10 editions and various translations. Cheyne recommended walking as the “most natural” and “most useful” exercise but considered riding on horseback as the “most manly” and “most healthy” (1734 reprint, p. 94). He also advocated exercises in the open air, such as tennis and dancing, and recommended cold baths and the use of the “flesh brush” to promote perspiration and improve circulation.

John Wesley's *Primitive Physic*, first published in 1747, was influenced to a large degree by George Cheyne. In his preface, Wesley noted that “the power of exercise, both to preserve and restore health, is greater than can well be conceived; especially in those who add temperance thereto” (1793 reprint, p. iv). William Buchan's classic *Domestic Medicine*, written in 1769, prescribed proper regimen for improving individual and family health. The book contained rules for the healthy and the sick and stressed the importance of exercise for good health in both children and adults.

During the 19th century, both the classical Greek tradition and the general hygiene movement were finding their way into the United States through American editions of western European medical treatises or through books on hygiene written by American physicians. The “self-help” era was also in

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full bloom during antebellum America. Early vestiges of a self-help movement had arisen in western Europe in the 16th century. As that century progressed, “laws of bodily health were expressed as value prescriptions” (Burns 1976, p. 208). Classical Greek preventive hygiene was part of formal medical training through the 18th century and continued on in the American health reform literature for most of the 19th century. During the latter period, an effort was made to popularize the Greek laws of health, to make each person responsible for the maintenance and balance of his or her health. Individual reform writers thus wrote about self-improvement, self-regulation, the responsibility for personal health, and self-management (Reiser 1985). If people ate too much, slept too long, or did not get enough exercise, they could only blame themselves for illness. By the same token, they could also determine their own good health (Cassedy 1977; Numbers 1977; Verbrugge 1981; Morantz 1984).

A.F.M. Willich’s *Lectures on Diet and Regimen* (1801) emphasized the necessity of exercise within the bounds of moderation. He included information on specific exercises, the time for exercise, and the duration of exercise. The essential advantages of exercise included increased bodily strength, improved circulation of the blood and all other bodily fluids, aid in necessary secretions and excretions, help in clearing and refining the blood, and removal of obstructions.

John Gunn’s classic *Domestic Medicine, Or Poor Man’s Friend*, was first published in 1830. His section entitled “Exercise” recommended temperance, exercise, and rest and valued nature’s way over traditional medical treatment. He also recommended exercise for women and claimed that all of the “diseases of delicate women” like “hysterics and hypochondria, arise from want of due exercise in the open, mild, and pure air” (1986 reprint; p. 109). Finally, in an interesting statement for the 1830s if not the 1990s, Gunn recommended a training system for all: “The advantages of the training systems are not confined to pedestrians or walkers—or to pugilists or boxers alone; or to horses which are trained for the chase and the race track; they extend to man in all conditions; and were training introduced into the United States, and made use of by physicians in many cases instead of medical drugs,

the beneficial consequences in the cure of many diseases would be very great indeed” (p. 113).

### Associating Physical Inactivity with Disease

Throughout history, numerous health professionals have observed that sedentary people appear to suffer from more maladies than active people. An early example is found in the writings of English physician Thomas Cogan, author of *The Haven of Health* (1584); he recommended his book to students who, because of their sedentary ways, were believed to be most susceptible to sickness.

In his 1713 book *Diseases of Workers*, Bernardino Ramazzini, an Italian physician considered the father of occupational medicine, offered his views on the association between chronic inactivity and poor health. In the chapter entitled “Sedentary Workers and Their Diseases,” Ramazzini noted that “those who sit at their work and are therefore called ‘chairworkers,’ such as cobblers and tailors, suffer from their own particular diseases.” He concluded that “these workers . . . suffer from general ill-health and an excessive accumulation of unwholesome humors caused by their sedentary life,” and he urged them to at least exercise on holidays “so to some extent counteract the harm done by many days of sedentary life” (1964 trans., pp. 281–285).

Shadrach Ricketson, a New York physician, wrote the first American text on hygiene and preventive medicine (Rogers 1965). In his 1806 book *Means of Preserving Health and Preventing Diseases*, Ricketson explained that “a certain proportion of exercise is not much less essential to a healthy or vigorous constitution, than drink, food, and sleep; for we see that people, whose inclination, situation, or employment does not admit of exercise, soon become pale; feeble, and disordered.” He also noted that “exercise promotes the circulation of the blood, assists digestion, and encourages perspiration” (pp. 152–153).

Since the 1860s, physicians and others had been attempting to assess the longevity of runners and rowers. From the late 1920s (Dublin 1932; Montoye 1992) to the landmark paper by Morris and colleagues (1953), observations that premature mortality is lower among more active persons than sedentary persons began to emerge and were later replicated in a variety of settings (Rook 1954;

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Brown et al. 1957; Pomeroy and White 1958; Zukel et al. 1959). The hypothesis that a sedentary lifestyle leads to increased mortality from coronary heart disease, as well as the later hypothesis that inactivity leads to the development of some other chronic diseases, has been the subject of numerous studies that provide the major source of data supporting the health benefits of exercise (see Chapter 4).

### Health, Physical Education, and Fitness

The hygiene movement found further expression in 19th century America through a new literature devoted to "physical education." In the early part of the century, many physicians began using the term in journal articles, speeches, and book titles to describe the task of teaching children the ancient Greek "laws of health." As Willich explained in his *Lectures on Diet and Regimen* (1801), "by physical education is meant the bodily treatment of children; the term physical being applied in opposition to moral" (p. 60). In his section entitled "On the Physical Education of Children," he continued to discuss stomach ailments, bathing, fresh air, exercise, dress, and diseases of the skin, among other topics. Physical education, then, implied not merely exercising the body but also becoming educated about one's body.

These authors were joined by a number of early 19th century educators. For example, an article entitled "Progress of Physical Education" (1826), which appeared in the first issue of *American Journal of Education*, declared that "the time we hope is near, when there will be no literary institution unprovided with the proper means to healthful exercise and innocent recreation, and when literary men shall cease to be distinguished by a pallid countenance and a wasted body" (pp. 19–20). Both William Russell, who was the journal's editor, and Boston educator William Fowler believed that girls as well as boys should have ample outdoor exercise. Knowledge about one's body also was deemed crucial to a well-educated and healthy individual by several physicians who, as Whorton has suggested, "dedicated their careers to birthing the modern physical education movement" (p. 282).

Charles Caldwell held a prominent position in Lexington, Kentucky's, Transylvania University Medical Department. Although he wrote on a variety of medical topics, his *Thoughts on Physical Education*

in 1834 gained him national recognition. Caldwell defined physical education as "that scheme of training, which contributes most effectually to the development, health, and perfection of living matter. As applied to man, it is that scheme which raises his whole system to its summit of perfection. . . . Physical education, then, in its philosophy and practice, is of great compass. If complete, it would be tantamount to an entire system of Hygiene. It would embrace every thing, that, by bearing in any way on the human body, might injure or benefit it in its health, vigor, and fitness for action" (pp. 28–29).

During the first half of the 19th century, systems of gymnastic and calisthenic exercise that had been developed abroad were brought to the United States. The most influential were exercises advanced by Per Henrik Ling in Sweden in the early 1800s and the "German system" of gymnastic and apparatus exercises that was based on the work of Johan Christoph GutsMuths and Friedrich Ludwig Jahn. Also, Americans like Catharine Beecher (1856) and Dioclesian Lewis (1883) devised their own extensive systems of calisthenic exercises intended to benefit both women and men. By the 1870s, American physicians and educators frequently discussed exercise and health. For example, physical training in relation to health was a regular topic in the *Boston Medical and Surgical Journal* from the 1880s to the early 1900s.

Testing of physical fitness in physical education began with the extensive anthropometric documentation by Edward Hitchcock in 1861 at Amherst College. By the 1880s, Dudley Sargent at Harvard University was also recording the bodily measurements of college students and promoting strength testing (Leonard and Affleck 1947). During the early 1900s, the focus on measuring body parts shifted to tests of vital working capacity. These tests included measures of blood pressure (McCurdy 1901; McKenzie 1913), pulse rate (Foster 1914), and fatigue (Storey 1903). As early as 1905, C. Ward Crampton, former director of physical training and hygiene in New York City, published the article "A Test of Condition" in *Medical News*. Attempts to assess physical fitness had constituted a significant aspect of the work of turn-of-the-century physical educators, many of whom were physicians.

Allegations that American conscripts during World War I were inadequately fit to serve their

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country helped shift the emphasis of physical education from health-related exercise to performance outcomes. Public concern stimulated legislation to make physical education a required subject in schools. But the financial austerities of the Great Depression had a negative effect on education in general, including physical education (Rogers 1934). At the same time, the combination of increased leisure time for many Americans and a growing national interest in college and high school sports shifted the emphasis on physical education away from the earlier aim of enhancing performance and health to a new focus on sports-related skills and the worthy use of leisure time.

Physical efficiency was a term widely used in the literature of the 1930s. Another term, physical condition, also found its way into research reports. In 1936, Arthur Steinhaus published one of the earliest articles on "physical fitness" in the *Journal of Health, Physical Education, and Recreation*; in 1938, C. H. McCloy's article "Physical Fitness and Citizenship" appeared in the same journal.

As the United States entered World War II, the federal government showed increasing interest in physical education, especially toward physical fitness testing and preparedness. In October 1940, President Franklin Roosevelt named John Kelly, a former Olympic rower, to the new position of national director of physical training. The following year, Fiorella La Guardia, the Mayor of New York City and the director of civilian defense for the Federal Security Agency, appointed Kelly as assistant in charge of physical fitness; tennis star Alice Marble was also chosen to promote physical fitness among girls and women (Park 1989; Berryman 1995).

In 1943, Arthur Steinhaus chaired a committee appointed by the Board of Directors of the American Medical Association to review the nature and role of exercise in physical fitness (Steinhaus et al. 1943), and C. Ward Crampton chaired a committee on physical fitness under the direction of the Federal Security Agency. Crampton and his 73-member advisory council were charged with developing physical fitness in the civilian population (Crampton 1941; Park 1989).

In 1941, Morris Fishbein, editor of the *Journal of the American Medical Association*, stated that "from the point of view on physical fitness we are a far

better nation now than we were in 1917," but he cautioned Americans not to believe "we have attained an optimum in physical fitness" (p. 54). He realized the magnitude of the fitness problem when he noted that the poor results of physical examinations reported by the Selective Service Boards were "a challenge to the medical profession, to the social scientists, the physical educators, the public health officials, and all those concerned in the United States with the physical improvement of our population" (p. 55). The goals most frequently cited for physical education between 1941 and 1945 were resistance to disease, muscular strength and endurance, cardio-respiratory endurance, muscular growth, flexibility, speed, agility, balance, and accuracy (Larson and Yocom 1951).

After World War II concluded, a continuing interest in physical fitness convinced other key members of the medical profession and the American Medical Association to continue studying exercise. Much of this interest can be attributed to the pioneering work of Thomas K. Cureton, Jr., and his Physical Fitness Research Laboratory at the University of Illinois (Shea 1993). Cardiologists, health education specialists, and physicians in preventive medicine were becoming aware of the contributions of exercise to the overall health and efficiency of the heart and circulatory system. In 1946, the American Medical Association's Bureau of Health Education designed and organized the Health and Fitness Program to provide "assistance to local organizations throughout the nation in the development of satisfactory health education programs" (Fishbein 1947, p. 1009). The program became an important link among physical educators, physicians, and physiologists.

The event that attracted the most public attention to physical fitness, including that of President Dwight D. Eisenhower, was the publication of the article "Muscular Fitness and Health" in the December 1953 issue of the *Journal of Health, Physical Education, and Recreation*. The authors, Hans Kraus and Ruth Hirschland of the Institute of Physical Medicine and Rehabilitation at the New York University Bellevue Medical Center, stated that 56.6 percent of the American schoolchildren tested "failed to meet even a minimum standard required for health" (p. 17). When this rate was compared with the 8.3 percent failure rate for European children, a



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call for reform went out. Kraus and Hirschland labeled the lack of sufficient exercise “a serious deficiency comparable with vitamin deficiency” and declared “an urgent need” for its remedy (pp. 17–19). John Kelly, the former national director of physical fitness during World War II, notified Pennsylvania Senator James Duff of these startling test results. Duff, in turn, brought the research to the attention of President Eisenhower, who invited several athletes and exercise experts to a meeting in 1955 to examine this issue in more depth. A President’s Conference on Fitness of American Youth, held in June 1956, was attended by 150 leaders from government, physical education, medical, public health, sports, civic, and recreational organizations. This meeting eventually led to the establishment of the President’s Council on Youth Fitness and the President’s Citizens Advisory Committee on the Fitness of American Youth (Hackensmith 1966; Van Dalen and Bennett 1971).

When John Kennedy became president in 1961, one of his first actions was to call a conference on physical fitness and young people. In 1963, the President’s Council on Youth Fitness was renamed the President’s Council on Physical Fitness. In 1968, the word “sports” was added to the name, making it the President’s Council on Physical Fitness and Sports (PCPFS). The PCPFS was charged with promoting physical activity, fitness, and sports for Americans of all ages.

During the 1960s, a number of educational and public health organizations published articles and statements on the importance of fitness for children and youths. The American Association for Health, Physical Education, and Recreation (AAHPER) expanded its physical fitness testing program to include college-aged men and women. The association developed new norms from data collected from more than 11,000 boys and girls 10–17 years old. The AAHPER also joined with the President’s Council on Physical Fitness to conduct the AAHPER Youth Fitness Test, which had motivational awards. In 1966, President Lyndon Johnson’s newly created Presidential Physical Fitness Award was incorporated into the program.

In the mid-1970s, the need to promote the health—rather than exclusively the performance—benefits of exercise and physical fitness began to reappear. In

1975, AAHPER stated it was time to differentiate physical fitness related to health from performance related to athletic ability (Blair, Falls, Pate 1983). Accordingly, AAHPER commissioned the development of the Health Related Physical Fitness Test. This move in youth fitness paralleled the adoption of the aerobic concept, which promoted endurance-type exercise among the public (Cooper 1968).

## Exercise Physiology Research and Health

The study of the physiology of exercise in a modern sense began in Paris, France, when Antoine Lavoisier in 1777 and Lavoisier and Pierre de Laplace in 1780 developed techniques to measure oxygen uptake and carbon dioxide production at rest and during exercise. During the 1800s, European scientists used and advanced these procedures to study the metabolic responses to exercise (Scharling 1843; Smith 1857; Katzenstein 1891; Speck 1889; Allen and Pepys 1809). The first major application of this research to humans—Edward Smith’s study of the effects of “assignment to hard labor” by prisoners in London in 1857—was to determine if hard manual labor negatively affected the health and welfare of the prisoners and whether it should be considered cruel and unusual punishment.

William Byford published “On the Physiology of Exercise” in the *American Journal of Medical Sciences* in 1855, and Edward Mussey Hartwell, a leading physical educator, wrote a two-part article, “On the Physiology of Exercise,” for the *Boston Medical and Surgical Journal* in 1887. The first important book on the subject, George Kolb’s *Beitrag zur Physiologie Maximaler Muskelarbeit Besonders des Modernen Sports*, was published in 1887 (trans. *Physiology of Sport*, 1893) (cited in Langenfeld 1988 and Park 1992). The following year, Fernand Lagrange’s *Physiology of Bodily Exercise* was published in France.

From the early 1900s to the early 1920s, several works on exercise physiology began to appear. George Fitz, who had established a physiology of exercise laboratory during the early 1890s, published his *Principles of Physiology and Hygiene* in 1908. R. Tait McKenzie’s *Exercise in Education and Medicine* (1909) was followed by such works as Francis Benedict and Edward Cathcart’s *Muscular Work, A Metabolic Study with Special Reference to the Efficiency of the Human Body as a Machine* (1913). The next year, a professor

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of physiology at the University of London, F.A. Bainbridge, published a second edition of *Physiology of Muscular Exercise* (Park 1981).

In 1923, the year Archibald Hill was appointed Jodrell Professor of Physiology at University College, London, the physiology of exercise acquired one of its most respected researchers and staunchest supporters, for Hill had won the Nobel Prize in Medicine and Physiology the year before. Hill's 1925 presidential address on "The Physiological Basis of Athletic Records" to the British Association for the Advancement of Science appeared in *The Lancet* (1925a) and *Scientific Monthly* (1925b), and in 1926 he published his landmark book *Muscular Activity*. The following year, Hill published *Living Machinery*, which was based largely on his lectures before audiences at the Lowell Institute in Boston and the Baker Laboratory of Chemistry in Ithaca, New York.

Several leading physiologists besides Hill were interested in the human body's response to exercise and environmental stressors, especially activities involving endurance, strength, altitude, heat, and cold. Consequently, they studied soldiers, athletes, aviators, and mountain climbers as the best models for acquiring data. In the United States, such research was centered in the Boston area, first at the Carnegie Nutrition Laboratory in the 1910s and later at the Harvard Fatigue Laboratory, which was established under the leadership of Lawrence Henderson in 1927 (Chapman and Mitchell 1965; Dill 1967; Horvath and Horvath 1973). That year, Henderson and colleagues first demonstrated that endurance exercise training improved the efficiency of the cardiovascular system by increasing stroke volume and decreasing heart rate at rest. Two years later, Schneider and Ring (1929) published the results of a 12-week endurance training program on one person, demonstrating a 24-percent increase in "crest load of oxygen" (maximal oxygen uptake). Over the next 15 years, a limited number of exercise training studies were published that evaluated the response of maximal oxygen uptake or endurance performance capacity to exercise training. These included noteworthy reports by Gemmill and colleagues (1931), Robinson and Harmon (1941), and Knehr, Dill, and Neufeld (1942) on endurance training responses by male college students. However, none of those early studies compared the

effects of different types, intensities, durations, or frequencies of exercise on performance capacity or health-related outcomes.

Activities surrounding World War II greatly influenced the research in exercise physiology, and several laboratories, including the Harvard Fatigue Laboratory, began directing their efforts toward topics of importance to the military. The other national concern that created much interest among physiologists was the fear (discussed earlier in this chapter), that American children were less fit than their European counterparts. Research was directed toward the concept of fitness in growth and development, ways to measure fitness, and the various components of fitness (Berryman 1995). Major advances were also made in the 1940s and 1950s in developing the components of physical fitness (Cureton 1947) and in determining the effects of endurance and strength training on measures of performance and physiologic function, especially adaptations of the cardiovascular and metabolic systems. Also investigated were the effects of exercise training on health-related outcomes, such as cholesterol metabolism (Taylor, Anderson, Keys 1957; Montoye et al. 1959).

Starting in the late 1950s and continuing through the 1970s, a rapidly increasing number of published studies evaluated or compared different components of endurance-oriented exercise training regimens. For example, Reindell, Roskamm, and Gerschler (1962) in Germany, Christensen (1960) in Denmark, and Yakovlev and colleagues (1961) in Russia compared—and disagreed—about the relative benefits of interval versus continuous exercise training in increasing cardiac stroke volume and endurance capacity. Other investigators began to evaluate the effects of different modes (Sloan and Keen 1959) and durations (Sinisalo and Juurtola 1957) of endurance-type training on physiologic and performance measures.

Karvonen and colleagues' (1957) landmark paper that introduced using "percent maximal heart rate reserve" to calculate or express exercise training intensity was one of the first studies designed to compare the effects of two different exercise intensities on cardiorespiratory responses during exercise. Over the next 20 years, numerous investigators documented the effects of different exercise training regimens on a variety of health-related outcomes among healthy

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men and women and among persons under medical care (Bouchard, Shephard, Stephens 1994). Many of these studies evaluated the effects of endurance or aerobic exercise training on cardiorespiratory capacity and were initially summarized by Pollock (1973). The American College of Sports Medicine (ACSM) (1975, 1978) and the American Heart Association (AHA) (1975) further refined the results of this research (see the section on "Evolution of Physical Activity Recommendations," later in this chapter).

Over the past two decades, experts from numerous disciplines have determined that exercise training substantially enhances physical performance and have begun to establish the characteristics of the exercise required to produce specific health benefits (Bouchard, Shephard, Stephens 1994). Also, behavioral scientists have begun to evaluate what determines physical activity habits among different segments of the population and are developing strategies to increase physical activity among sedentary persons (Dishman 1988). The results of much of this research are cited in the other chapters of this report and were the focus of the various conferences, reports, and guidelines summarized later in this chapter.

As the literature of exercise science has matured and recommendations have evolved, certain widely agreed-on terms have emerged. Because a number of these occur throughout the rest of this chapter and report, they are presented and briefly defined in the following section.

### Terminology of Physical Activity, Physical Fitness, and Health

This section discusses four broad terms used frequently in this report: physical activity, exercise (or exercise training), physical fitness, and health. Also included is a glossary (Table 2-1) of more specific terms and concepts crucial to understanding the material presented in later parts of this chapter and report.

**Physical activity.** Physical activity is defined as bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above the basal level. Physical activity can be categorized in various ways, including type, intensity, and purpose.

Because muscle contraction has both mechanical and metabolic properties, it can be classified by

either property. This situation has caused some confusion. Typically, mechanical classification stresses whether the muscle contraction produces movement of the limb: isometric (same length) or static exercise if there is no movement of the limb, or isotonic (same tension) or dynamic exercise if there is movement of the limb. Metabolic classification involves the availability of oxygen for the contraction process and includes aerobic (oxygen available) or anaerobic (oxygen unavailable) processes. Whether an activity is aerobic or anaerobic depends primarily on its intensity. Most activities involve both static and dynamic contractions and aerobic and anaerobic metabolism. Thus, activities tend to be classified according to their dominant features.

The physical activity of a person or group is frequently categorized by the context in which it occurs. Common categories include occupational, household, leisure time, or transportation. Leisure-time activity can be further subdivided into categories such as competitive sports, recreational activities (e.g., hiking, cycling), and exercise training.

**Exercise (or exercise training).** Exercise and physical activity have been used synonymously in the past, but more recently, exercise has been used to denote a subcategory of physical activity: "physical activity that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is the objective" (Caspersen, Powell, Christensen 1985). Exercise training also has denoted physical activity performed for the sole purpose of enhancing physical fitness.

**Physical fitness.** Physical fitness has been defined in many ways (Park 1989). A generally accepted approach is to define physical fitness as the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies. Physical fitness thus includes cardiorespiratory endurance, skeletal muscular endurance, skeletal muscular strength, skeletal muscular power, speed, flexibility, agility, balance, reaction time, and body composition. Because these attributes differ in their importance to athletic performance versus health, a distinction has been made between performance-related fitness and health-related fitness (Pate 1983; Caspersen, Powell, Christensen 1985). Health-related fitness has been

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Table 2-1. Glossary of terms

**Aerobic training**—Training that improves the efficiency of the aerobic energy-producing systems and that can improve cardiorespiratory endurance.\*

**Agility**—A skill-related component of physical fitness that relates to the ability to rapidly change the position of the entire body in space with speed and accuracy.†

**Anaerobic training**—Training that improves the efficiency of the anaerobic energy-producing systems and that can increase muscular strength and tolerance for acid-base imbalances during high-intensity effort.\*

**Balance**—A skill-related component of physical fitness that relates to the maintenance of equilibrium while stationary or moving.†

**Body composition**—A health-related component of physical fitness that relates to the relative amounts of muscle, fat, bone, and other vital parts of the body.†

**Calorimetry**—Methods used to calculate the rate and quantity of energy expenditure when the body is at rest and during exercise.\*

**Direct calorimetry**—A method that gauges the body's rate and quantity of energy production by direct measurement of the body's heat production; the method uses a calorimeter, which is a chamber that measures the heat expended by the body.\*

**Indirect calorimetry**—A method of estimating energy expenditure by measuring respiratory gases. Given that the amount of O<sub>2</sub> and CO<sub>2</sub> exchanged in the lungs normally equals that used and released by body tissues, caloric expenditure can be measured by CO<sub>2</sub> production and O<sub>2</sub> consumption.\*

**Cardiorespiratory endurance (cardiorespiratory fitness)**—A health-related component of physical fitness that relates to the ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity.†

**Coordination**—A skill-related component of physical fitness that relates to the ability to use the senses, such as sight and hearing, together with body parts in performing motor tasks smoothly and accurately.†

**Detraining**—Changes the body undergoes in response to a reduction or cessation of regular physical training.\*

**Endurance training/endurance activities**—Repetitive, aerobic use of large muscles (e.g., walking, bicycling, swimming).‡

**Exercise (exercise training)**—Planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness.

**Flexibility**—A health-related component of physical fitness that relates to the range of motion available at a joint.\*

**Kilocalorie (kcal)**—A measurement of energy. 1 kilocalorie = 1 Calorie = 4,184 joules = 4.184 kilojoules.

**Kilojoule (kJoule)**—A measurement of energy. 4.184 kilojoules = 4,184 joules = 1 Calorie = 1 kilocalorie.

**Maximal heart rate reserve**—The difference between maximum heart rate and resting heart rate.\*

**Maximal oxygen uptake ( $\dot{V}O_2$  max)**—The maximal capacity for oxygen consumption by the body during maximal exertion. It is also known as aerobic power, maximal oxygen consumption, and cardiorespiratory endurance capacity.\*

**Maximal heart rate (HR max)**—The highest heart rate value attainable during an all-out effort to the point of exhaustion.\*

**Metabolic equivalent (MET)**—A unit used to estimate the metabolic cost (oxygen consumption) of physical activity. One MET equals the resting metabolic rate of approximately 3.5 ml O<sub>2</sub> • kg<sup>-1</sup> • min<sup>-1</sup>.\*

**Muscle fiber**—An individual muscle cell.\*

**Muscular endurance**—The ability of the muscle to continue to perform without fatigue.\*

**Overtraining**—The attempt to do more work than can be physically tolerated.\*

**Physical activity**—Bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure.

**Physical fitness**—A set of attributes that people have or achieve that relates to the ability to perform physical activity.

**Power**—A skill-related component of physical fitness that relates to the rate at which one can perform work.

**Relative perceived exertion (RPE)**—A person's subjective assessment of how hard he or she is working. The Borg scale is a numerical scale for rating perceived exertion.\*

**Reaction time**—A skill-related component of physical fitness that relates to the time elapsed between stimulation and the beginning of the reaction to it.†

**Resistance training**—Training designed to increase strength, power, and muscle endurance.\*

**Resting heart rate**—The heart rate at rest, averaging 60 to 80 beats per minute.\*

**Retraining**—Recovery of conditioning after a period of inactivity.\*

**Speed**—A skill-related component of physical fitness that relates to the ability to perform a movement within a short period of time.†

**Strength**—The ability of the muscle to exert force.\*

**Training heart rate (THR)**—A heart rate goal established by using the heart rate equivalent to a selected training level (percentage of  $\dot{V}O_2$  max). For example, if a training level of 75 percent  $\dot{V}O_2$  max is desired, the  $\dot{V}O_2$  at 75 percent is determined and the heart rate corresponding to this  $\dot{V}O_2$  is selected as the THR.\*

\*From Wilmore JH, Costill DL. *Physiology of sport and exercise*. Champaign, IL: Human Kinetics, 1994.

†From Corbin CB, Lindsey R. *Concepts in physical education with laboratories*. 8th ed. Dubuque, IA: Times Mirror Higher Education Group, 1994.

‡Adapted from Corbin CB, Lindsey R, 1994, and Wilmore JH, Costill DL, 1994.

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said to include cardiorespiratory fitness, muscular strength and endurance, body composition, and flexibility. The relative importance of any one attribute depends on the particular performance or health goal.

**Health.** The 1988 International Consensus Conference on Physical Activity, Physical Fitness, and Health (Bouchard et al. 1990) defined health as “a human condition with physical, social, and psychological dimensions, each characterized on a continuum with positive and negative poles. Positive health is associated with a capacity to enjoy life and to withstand challenges; it is not merely the absence of disease. Negative health is associated with morbidity and, in the extreme, with premature mortality.” Thus, when considering the role of physical activity in promoting health, one must acknowledge the importance of psychological well-being, as well as physical health.

## Evolution of Physical Activity Recommendations

In the middle of the 20th century, recommendations for physical activity to achieve fitness and health benefits were based on systematic comparisons of effects from different profiles of exercise training (Cureton 1947; Karvonen, Kentala, Mustala 1957; Christensen 1960; Yakolav et al. 1961; Reindell, Roskamm, Gerschler 1962). In the 1960s and 1970s, expert panels and committees, operating under the auspices of health- or fitness-oriented organizations, began to recommend specific physical activity programs or exercise prescriptions for improving physical performance capacity or health (President's Council on Physical Fitness 1965; AHA 1972, 1975; ACSM 1975). These recommendations were based on substantial clinical experience and on scientific data available at that time.

Pollock's 1973 review of what type of exercise was needed to improve aerobic power and body composition subsequently formed the basis for a 1978 position statement by the ACSM titled “The Recommended Quantity and Quality of Exercise for Developing and Maintaining Fitness in Healthy Adults.” This statement outlined the exercise that healthy adults would need to develop and maintain cardiorespiratory fitness and healthy body composition. These guidelines recommended a frequency of

exercise training of 3–5 days per week, an intensity of training of 60–90 percent of maximal heart rate (equivalent to 50–85 percent of maximal oxygen uptake or heart rate reserve), a duration of 15–60 minutes per training session, and the rhythmical and aerobic use of large muscle groups through such activities as running or jogging, walking or hiking, swimming, skating, bicycling, rowing, cross-country skiing, rope skipping, and various endurance games or sports (Table 2-2).

Between 1978 and 1990, most exercise recommendations made to the general public were based on this 1978 position statement, even though it addressed only cardiorespiratory fitness and body composition. By providing clear recommendations, these guidelines proved invaluable for promoting cardiorespiratory endurance, although many people overinterpreted them as guidelines for promoting overall health. Over time, interest developed in potential health benefits of more moderate forms of physical activity, and attention began to shift to alternative physical activity regimens (Haskell 1984; Blair, Kohl, Gordon 1992; Blair 1993).

In 1990, the ACSM updated its 1978 position statement by adding the development of muscular strength and endurance as a major objective (ACSM 1990). The recommended frequency, intensity, and mode of exercise remained similar, but the duration was slightly increased from 15–60 minutes to 20–60 minutes per session, and moderate-intensity resistance training (one set of 8–12 repetitions of 8–10 different exercises at least 2 times per week) was suggested to develop and maintain muscular strength and endurance (Table 2-2). These 1990 recommendations also recognized that activities of moderate intensity may have health benefits independent of cardiorespiratory fitness:

*Since the original position statement was published in 1978, an important distinction has been made between physical activity as it relates to health versus fitness. It has been pointed out that the quantity and quality of exercise needed to obtain health-related benefits may differ from what is recommended for fitness benefits. It is now clear that lower levels of physical activity than recommended by this position statement may reduce the risk for certain chronic degenerative diseases*

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*and yet may not be of sufficient quantity or quality to improve [maximal oxygen uptake]. ACSM recognizes the potential health benefits of regular exercise performed more frequently and for longer duration, but at lower intensities than prescribed in this position statement.*

In conjunction with a program to certify exercise professionals at various levels of experience and competence, the ACSM has published five editions of *Guidelines for Exercise Testing and Prescription* (ACSM 1975, 1980, 1986, 1991, 1995b) that describe the components of the exercise prescription and explain how to initiate and complete a proper exercise training program (Table 2-2). The ACSM has also published recommendations on the role of exercise for preventing and managing hypertension (1993) and for patients with coronary heart disease (1994) and has published a position stand on osteoporosis (1995a). For the most part, newer recommendations that focus on specific health outcomes are consistent with the ACSM's 1978 and 1990 position statements, but they generally expand the range of recommended activities to include moderate-intensity exercise.

Between the 1960s and 1990s, other U.S. health and fitness organizations published recommendations for physical activity. Because these organizations used the same scientific data as the ACSM, their position statements and guidelines are similar. A notable example is *Healthy People 2000* (USDHHS 1990), the landmark publication of the U.S. Public Health Service that lists various health objectives for the nation. (The objectives for physical activity and fitness, as revised in 1995 [USDHHS 1995], are included as Appendix A of this chapter.) Other recommendations include specific exercise programs developed for men and women by the President's Council on Physical Fitness (1965) and the YMCA (National Council YMCA 1989). The AHA (1972, 1975, 1992, 1993, 1994, 1995) has published for both health professionals and the public a series of physical activity recommendations and position statements directed at CHD prevention and cardiac rehabilitation. In 1992, the AHA published a statement identifying physical inactivity as a fourth major risk factor for CHD, along with smoking, high blood pressure, and high blood cholesterol (Fletcher et al. 1992). The American Association of Cardiovascular

and Pulmonary Rehabilitation has also published guidelines for using physical activity for cardiac (1991, 1995) and pulmonary (1993) rehabilitation. Some of these recommendations provide substantial advice to ensure that exercise programs are safe for people at increased risk for heart disease or for patients with established disease.

Between the 1970s and the mid-1990s, exercise training studies conducted on middle-aged and older persons and on patients with lower functional capacity demonstrated that significant cardiorespiratory performance and health-related benefits can be obtained at more moderate levels of activity intensity than previously realized. In addition, population-based epidemiologic studies demonstrated dose-response gradients between physical activity and health outcomes. As a result of these findings, the most recent CDC-ACSM guidelines recommend that all adults perform 30 or more minutes of moderate-intensity physical activity on most, and preferably all, days—either in a single session or “accumulated” in multiple bouts, each lasting at least 8–10 minutes (Pate et al. 1995). This guideline thus significantly differs from the earlier ones on three points: it reduces the minimum starting exercise intensity from 60 percent of maximal oxygen uptake to 50 percent in healthy adults and to 40 percent in patients or persons with very low fitness; it increases the frequency of exercise sessions from 3 days per week to 5–7 days per week, depending on intensity and session duration; and it includes the option of accumulating the minimum of 30 minutes per day in multiple sessions lasting at least 8–10 minutes (Pate et al. 1995). This modification in advice acknowledges that people who are sedentary and who do not enjoy, or are otherwise not able to maintain, a regimen of regular, vigorous activity can still derive substantial benefit from more moderate physical activity as long as it is done regularly.

The NIH Consensus Development Conference Statement on Physical Activity and Cardiovascular Health identifies physical inactivity as a major public health problem in the United States and issues a call to action to increase physical activity levels among persons in all population groups. (See Appendix B for full text of the recommendations.) The core recommendations, similar to those jointly made by the CDC and the ACSM (Pate et al. 1995), call for

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**Table 2-2. Selected physical activity recommendations in the United States (1965–1996)**

Source	Objective	Type/mode
PCPF (1965)	Physical fitness	General fitness
AHA Recommendations (1972)	CHD prevention	Endurance
YMCA (1973)	General health and fitness	Endurance, strength, flexibility
ACSM Guidelines (1975)	Cardiorespiratory fitness	Endurance, strength, flexibility
AHA Recommendations (1975)	Secondary prevention in patients with heart disease	Endurance
ACSM Position Statement (1978)	Cardiorespiratory fitness and body composition	Endurance
USDHEW–Healthy People (1979)	Disease prevention/health promotion	Endurance
ACSM Guidelines (1980)	Cardiorespiratory fitness	Endurance, strength, flexibility
ACSM Guidelines (1986)	Cardiorespiratory fitness	Endurance, strength, flexibility
USDHHS–Surgeon General’s Report on Nutrition and Health (1988)	Weight control	Endurance
USPSTF (1989)	Primary prevention in clinical practice	Not specified, implied endurance
ACSM Position Stand (1990)	Cardiorespiratory and muscular fitness	Endurance, strength
ACSM Guidelines (1991)	Cardiorespiratory fitness	Endurance, strength, flexibility
USHHS/USDA Dietary Guidelines (1990)	Health promotion/disease prevention, weight maintenance	Not specified
AACVPR (1991)	Cardiac rehabilitation	Endurance, strength
DHHS-Healthy People 2000 (1991)*	Disease prevention/health promotion	Endurance, strength, flexibility
AHA Position Statement (1992)	CVD prevention and rehabilitation	Endurance
AHA Standards (1992 and 1995)	CHD prevention and rehabilitation	Endurance, strength
AACVPR (1993)	Pulmonary rehabilitation	Endurance
ACSM Position Statement (1993)	Prevention and treatment of hypertension	Endurance, strength

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Intensity	Endurance		Resistance training
	Frequency	Duration	
Five levels	5 x week	Approximately 30 minutes	Selected calisthenics
70–85% MHR	3–7 x week	15–20 minutes	Not addressed
80% $\dot{V}O_2$ max	3 x week	40–45 minutes	Not specified
60–90% $\dot{V}O_2$ max 60–90% HRR	3 x week	20–30 minutes	Not specified
70–85% MHR	3–4 x week	20–60 minutes	Not addressed
50–85% $\dot{V}O_2$ max 50–85% HRR 60–90% MHR	3–5 x week	15–60 minutes	Not addressed
Moderate/hard	3 x week	15–30 minutes	Not addressed
50–85% $\dot{V}O_2$ max/HRR 60–90% MHR	3–5 x week	15–60 minutes	Not specified
50–85% $\dot{V}O_2$ max/HRR 60–90% MHR	3–5 x week	15–60 minutes	Not specified
Not specified	≥ 3 x week	≥ 20 minutes	Not addressed
At least moderate	Not specified	Not specified	Not addressed
50–85% $\dot{V}O_2$ max 50–85% HRR 60–90% MHR	3–5 x week	20–60 minutes	1 set, 8–12 repetitions 8–10 exercises 2 days x week
40–85% $\dot{V}O_2$ max 55–90% MHR RPE = 12–16	3–5 x week	15–60 minutes	Not specified
Not specified	Not specified	Not specified	Not addressed
Exercise following ACSM (1986) and AHA (1983) recommendations	3–5 x week	15–60 minutes	1–3 sets, 12–15 repetitions major muscle groups 2–3 days x week
Light/moderate/vigorous	3–5 x week	20–30 minutes	Not specified
> 50% $\dot{V}O_2$ max	3–4 x week	30–60 minutes	Not addressed
50–60% $\dot{V}O_2$ max 50–60% HR reserve	≥ 3 x week	≥ 30 minutes	1 set, 10–15 repetitions 8–10 exercises, 2–3 days x week
60% HR reserve	3 x week	20–30 minutes	Not addressed
40–70% $\dot{V}O_2$ max	3–5 x week	20–60 minutes	Not specified