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Benefits of Bicycling and Walking to Health

National Bicycling And Walking Study

U.S. Department of Transportation

Federal Highway Administration

Foreword

This case study was prepared under contract for the Federal Highway Administration by Edmund R. Burke, Ph.D. Additional assistance was provided by the Bicycle Federation of America.

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National Bicycling and Walking Study
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Executive Summary

The *Benefits of Bicycling and Walking to Health* is one of a series of reports mandated by the National Bicycling and Walking Study. The major emphasis of this report is to provide information on the potential health benefits and deleterious health effects accruing to individuals and the nation as a whole while engaging in bicycling and walking.

This document is intended to assist officials and citizens in determining current levels of use of bicycling and walking, to give reasons why bicycling and walking are not used more for transportation and recreation in the United States, and to show the health economic costs and benefits of promoting these activities for health and fitness. The document indicates how interest in bicycling and walking may be increased through safety education, improved employer relationships, and pedestrian heightened awareness of this right to travel in a healthy environment.

Bicycle and walking strategies generally appear among the most popular transportation measures. This is not surprising since many individuals say a major motivation for bicycling or walking is for enjoyment, and because walking and bicycling provide an opportunity for physical exercise at the same time a trip is made. Other appealing features of bicycling and walking include energy conservation and reduction in air and noise pollution, which will have a positive impact upon our environment. Finally, these activities are used as popular modes of exercise and rehabilitation for individuals with certain diseases and injuries.

Chapter 1: Patterns of Bicycling and Walking Use

This chapter summarizes the key reasons individuals begin cycling and walking programs and stay with them. These activities have seen an increase in popularity, partly owing to the emergence of a new environmental consciousness, increased awareness of health concerns, recommendations from the medical and health care community, and the need for economical recreation and commuting.

Several surveys have indicated the predominant factors deterring individuals from bicycling and walking are risks of accidents, exposure to pollution, inclement weather, hilly environments, and wider availability of cars and public transport. Increased safety is a key issue for increased participation. Ironically, pedestrians and bicyclists who are most at risk of injury and most exposed to air and noise pollution are the ones making the least contribution to these public

hazards. Walking and bicycling are nonpolluting means of travel, which is a positive benefit overlooked in policy making on reducing pollution from transport sources.

Bicycling and walking will continue to increase in use for fitness and transportation, but individuals have the right to participate in these activities in a healthy environment and to freely enjoy the amenities offered in public areas under conditions that adequately safeguard physical and psychological well-being. The case for promoting bicycling and walking is considerably strengthened by the huge increase in traffic forecasts for the next few decades.

Chapter 2. The Health and Fitness Benefits of Bicycling and Walking

The evidence presented in this chapter strongly supports the beneficial impact of exercise and physical activity on various measures of functional capacity, disability, morbidity, and mortality. Although potential problems such as orthopedic injuries can develop from walking and accidents can happen while bicycling, evidence at present supports a favorable risk/benefit ratio for regular participation in such activities as walking and bicycling. Despite improvements seen in recent years, most Americans are still sedentary, and large-scale public health intervention efforts are needed to further encourage regular exercise.

In this context, walking and bicycling offer numerous health benefits for the United States. Both activities not only improve the quality of life and individual health, but they also improve the health of others because of the reduced air and noise pollution, and have a positive impact on the earth's environment. The use of walking and bicycling to work and for recreation may offer some benefit to national health standards and is a logical activity deserving of continued emphasis and study.

Chapter 3. Environmental Factors Affecting Bicycling and Walking Use

Transportation, ecology, and economics are woven into our lifestyle and related to health and fitness. A partial solution to environmental concerns is self-propelled movement. Bicycling and walking for commuting are not the complete answer to urban transportation in the United States, but they can have a major impact on decreasing motor vehicle use.

One thing is certain. The replacement of motor vehicles with walking and bicycling would considerably reduce the level of air and noise pollution. This would also make a major contribution to the reduction in production of greenhouse gases, which is currently a major concern in the international political agenda.

Chapter 4: Hazards and Injuries Associated with Bicycling and Walking

As more and more people use walking and bicycling as a means of transportation and recreation, we need to respond to their growing concerns of safety. Fear for safety is the major concern of most individuals for not increasing the use of walking and cycling in their daily lives. Consideration needs to be given to implementing programs of safety and skill education, promoting increased helmet use in bicycling, and making the environment in which these activities are practiced less dangerous. The above items are major concerns for future study and development.

Chapter 5: Bicycling and Walking in Rehabilitation Settings

A regular program of walking and bicycling can be effective in battling the aging process or aid in rehabilitation of injuries or disease. Walking and bicycling are gentle, nonjarring activities that promote joint and bone density, build muscle, and counteract the slow degeneration of the musculoskeletal system. Moreover, while bicycling and walking cannot prevent diseases such as multiple sclerosis and various forms of arthritis and Parkinson's disease, they can serve as major forms of rehabilitative exercise for many chronic diseases and injuries.

In addition, since cardiovascular disease is the number one killer in the United States, the addition of walking or bicycling for transportation or recreation to other lifestyle changes can reduce the risk of heart disease.

1. Patterns of Bicycling and Walking Use

This document, mandated by the National Bicycling and Walking Study, is one of a series of reports that will try to seek answers to some basic questions: How many people could commute by walking and bicycling? Why aren't bicycling and walking more popular now? How could these modes of transportation be encouraged?

The purpose of this report is to provide information on the potential health benefits and deleterious health effects accruing to individuals and to the nation as a whole while engaging in bicycling and walking. More specifically, the document is intended to help transportation planners, local officials, air quality planners, and citizens identify gaps in our knowledge, and details how those gaps can be filled in the areas of health relating to bicycling and pedestrian transportation. Based on literature reviews and discussions with bicycling and walking administration and health personnel, the report summarizes health information that may directly affect bicycling and walking.

Current Bicycle Use

In recent years, bicycling has grown in popularity, partly owing to the emergence of a new environmental and health consciousness in our country. A rapidly increasing proportion of the population is using bicycling for recreational pursuits. In 1991, the Bicycle Institute of America reported that 96 million individuals rode bicycles. Adults (persons 16 and over) comprised 54 percent of the group, with children 46 percent. Females lead the group with 55 percent of the 96 million and males at 45 percent (1).

Category uses for bicycles reported by the Bicycle Institute are as follows:

• Adults cycling regularly (average once per week)	27.5 million
• Bicycle commuters	4 million
• Individuals touring or vacationing by bike	1.5 million
• Recreational event participants	3.5 million
• Mountain bike cyclists	20 million
• Adults riding in competition (racing)	240 thousand

Only exercise walking and swimming drew more participants than bicycling in 1990 as reported by the National Sporting Goods Association (NSGA). The report cited that 55.3 million cyclists over the age of 7 participated in bicycling over six times in one year. They mention that women were over 50 percent of the participants in 1990 (2).

Results of a recent study done by the Sporting Goods Manufacturers Association (SGMA) showed that a little over 5 million Americans rode their bicycle over 100 days per year and are classified as "core" or "frequent" participants and listed mountain biking with over 700,000 individuals who rode over 52 days in 1990 (3).

The "First Major Study of the U.S. Bicycling Market" was conducted by the National Family Opinion, which surveyed 150,000 households. Adults 18 and older who had purchased a bicycle in the last year were initially interviewed in phase one of the study. Response to phase one was 69.2 percent.

In phase two of the project, 4,000 families were selected with about 1,000 questionnaires sent out to four different groups based upon their riding habits. The response from all groups in phase two of the study was 77 percent.

The survey qualified respondents and broke them down into four groups: enthusiasts, moving-ups, casuals, and infrequents. The information has recently been made available to the public by *Bicycling Magazine* (4). The major emphasis was to go beyond the 80 to 100 million cyclists who ride their bicycle more than one time per year.

Enthusiasts represented 2.7 percent of the new bike owners, by riding 128 miles per month. Moving-ups made up 7.3 percent of the group and ride an average of 37 miles per month.

Casual riders are 20.8 percent of the survey and ride only 15 miles per month. This group is the largest group of new bicycle owners (69.2 percent) representing 43.2 percent of all new bicycle sales volume. Infrequent cyclists only ride 10 miles per month.

The survey also asked, "Why do you cycle?" Almost 41 percent of the enthusiasts said it was for fast recreation, while 50 percent of the infrequents said it was for family togetherness. Interestingly, 30 percent of the enthusiasts, 38 percent of the moving-ups, and 47 percent of the casuals also ride for family togetherness. Only 12 percent of the enthusiasts are interested in weekend touring, dropping to only 7 percent of the moving-ups.

What would make consumers ride more often? The categories showed a fairly even break, with companionship definitely in the lead across the board, ranging from 44 percent of the enthusiasts, 49 percent of the moving-ups, 46 percent of the infrequents, and 46 percent of the casuals.

The next largest response was the need for safer places to ride, with 38 percent of the enthusiasts, 40 percent of the moving-ups, 39 percent of the casuals, and 32 percent of the infrequents choosing this category.

The appeal of riding in organized events (tours, centuries) did not fare very well in any of the groups. Only 12 percent of the enthusiasts, 9 percent of the moving-ups, 7 percent of the casuals, and 3 percent of the infrequents said that organized events would make them ride more.

Safer places to ride is the key issue that would encourage more people to ride for recreation and health.

The study also estimated that there were approximately 3 million bicycle commuters in the United States, and that with the proper incentives such as safer places to ride and places to park their bicycle, this number of bicyclists would rise dramatically (5).

Recently, *Bicycling Magazine* reported that a 1991 survey conducted by the Harris Poll Organization stated that 82 million adults bicycle, that 82 percent do it for recreation and 65 percent for fitness, and that the commuting number remained about the same at 3 million. However, if safer bicycle lanes on roads were established, 38 million recreational bicyclists would ride a bicycle sometimes to work.

When asked if they would bicycle to work if showers, lockers, and a secure bike storage were available, nearly 40 million reported they would commute occasionally or more often (6).

Current Walkers

In the 1980's, walking seemed to burst into public consciousness as a newly discovered activity. A 1985 survey conducted by the Sporting Goods Manufacturing Association (SGMA) indicated that more than 8 million people in North America had adopted walking as their major fitness activity in that year, making it the fastest-growing participant sport.

The SGMA reported in 1990 that 14.8 million Americans walked over 100 days per year and qualified them as "core" and "frequent" sports participants (3).

Exercise walking drew 71.3 million participants in 1990, according to the National Sporting Goods Association (2), and had the second-highest growth rate over the last 5 years. This survey included individuals over the age of 7 who participated in walking at least six times that year.

Enthusiasm for walking has existed in the medical profession for many years. Results of a 1983 survey of 1,751 primary care physicians indicated that walking was by far the most common health and fitness activity recommended by physicians (7).

A *Prevention Magazine* Report from research conducted by Louis Harris Poll in 1990 reported on the walking habits of 1,254 randomly selected adults in the continental United States (8). Results are projectable to the nation as a whole. Category uses for walking are:

- Seventy-three percent of Americans over the age of 18 say that during the past month they did some walking for exercise. Most of these people are regular walkers. Sixty-two percent—some 82 million—say they walk several times per week or more. And more than half of this group walks for exercise every day.

- Fifty-eight percent of walkers report that when they do walk they usually walk more than a mile—up from 52 percent in 1987. Thirty percent walk less than a mile and 11 percent walk exactly 1 mile.

- The percentage of women who walked was 79 percent and men was 67 percent.

- People over the age of 50 are much more likely to walk regularly than those under 50. Only 42 percent of those aged 18 to 49 are regular walkers, compared to 46 percent of those aged 50 to 64 and 54 percent of those aged 65 plus.

As with bicycling, more individuals would walk if the danger from traffic accidents could be reduced. Hillman and Cleary have reported that motorcycling, walking, and bicycling have the highest casualty rates per kilometer traveled. Indeed, the fatality rate for walking is 18 times higher than that for car travel (9). Current patterns of traffic and planning, which induce stress as well as fear and anxiety about the risk of an accident occurring, actually deter people from keeping fit in this potentially convenient way (10).

Summary

Fitness, recreation, and health are key reasons why individuals begin bicycling and walking programs and staying with them. In addition, walking and bicycling have seen an increase in popularity, partly owing to the emergence of a new environmental consciousness, increased awareness of health concerns, recommendations from medical and health care professionals, and need for economical recreation and commuting.

Louis Harris polls commissioned by Rodale Press and conducted in 1990 and 1991 have indicated the predominant factors deterring people from bicycling and walking are risks of accident, hilly environments, exposure to automobile pollution, inclement weather, and the wider availability of public transport and cars. Theft of bicycles was also mentioned by bicyclists and requests were made for more secure bike storage facilities. Most of the respondents want their town or locale to adopt an overall transportation planning structure "that would make walking and bicycling safe and integral part of the area's transportation system" (11).

Ironically, pedestrians and bicyclists who are the most at risk of injury and most exposed to air pollution are the ones making the least contribution to these public hazards. Walking and bicycling are nonpolluting means of travel, which is a positive benefit overlooked in policy on reducing pollution from transport sources.

Despite the relatively high level of use of walking and bicycling in this country for recreation and fitness, the potential of bicycle transportation is still relatively untapped compared to other industrial countries. Developed countries in which these means of transportation and recreational activities are high include many in Northern Europe. In the Netherlands, bicycling is the most important means of transportation and virtually every family owns a bicycle. Forty percent use a bicycle every day and 80 percent ride a bicycle occasionally in the Netherlands (12). In these countries, bicycling and walking are accepted uses of transportation for adults. In the United States, this form of acceptance seems to exist in a growing number of communities, such as Davis, CA, and Madison, WI, where existing levels of bicycling and walking are high. What has been learned and put into practice in these communities needs to be emulated across the United States.

In conclusion, cycling and walking will continue to increase in use for fitness and transportation, but the pedestrian has the right to travel in a healthy environment and to freely enjoy the amenities offered in public areas under conditions that adequately safeguard his or her physical and psychological well-being. The case of promoting bicycling and walking is considerably strengthened by the huge increase in traffic forecasts for the next few decades. This increase flies in the face of national and international policy on environmental concerns of taking action to avert global pollution and climatic changes.

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2. The Health and Fitness Benefits of Bicycling and Walking

This chapter examines the health and fitness aspects of bicycling and walking, perhaps the least researched area of governmental policy on bicycling and walking. This area may provide, though, the most compelling reason for encouraging increased participation in these activities. First, we will explore some of the general aspects of fitness and health, and report on the growing body of evidence that shows regular exercise improves health. Next, discussion of common causes of mortality and morbidity will be considered to see how increased levels of exercise are considered to be preventative and therapeutic. Subsequently, what the contribution of walking and bicycling could make to the health of the nation as a whole will be discussed in this chapter (1).

Physical Activity and Cardiovascular Health

Epidemiological studies started in the 1950's began to link physical activity to decreased incidence of heart disease and sudden death. London bus conductors (on their feet all day collecting fares), physically active railroad workers, postmen, and longshoremen doing heavy physical activity have all been found to have fewer heart attacks than more sedentary fellow workers (2, 3, 4).

Perhaps the most convincing evidences linking physical activity to improved cardiovascular health has come from four studies published in recent years. In the College Alumni Study, in which 16,000 men who entered college between 1916 and 1950 have been tracked for more than 25 years, individuals who regularly expended between 500 and 3,500 calories in physical activity per week showed reductions in myocardial infarction and sudden death when compared with more sedentary counterparts (5).

A report from the Multiple Risk Factor Intervention Trial showed that even low-intensity activity (such as walking) results in significant reduction in the manifestations of coronary heart disease (6). The Centers for Disease Control analysis of 43 previous exercise studies showed a significant decrease in the incidence of heart disease in the most active groups of individuals when compared to inactive or sedentary individuals (7).

A recent report from the Aerobics Center, Dallas, TX, studied the physical fitness and all-cause and cause-specific mortality in 10,224 men and 3,120 women who were followed for about 8 years. Treadmill tests were used to group participants into fitness categories. The bottom 20 percent were classified as low-fit, the middle 40 percent moderate-fit, and the top 40 percent as high-fit.

Men and women in the low-fit category were more than twice as likely to die from cancer, cardiovascular disease, and from all causes combined than participants in the moderate-fit group. The lowest death rates were seen in the high-fit group. Training for moderate fitness equaled walking 2 miles in less than 30 minutes, 3 days per week. Attributable risk estimates for all-cause mortality indicated that low physical fitness was an important risk factor in both men and women. Higher levels of physical fitness appear to delay all-cause mortality primarily due to lower rates of cardiovascular disease and cancer (8).

Lack of exercise and low levels of physical fitness are very important risk factors for disease and early death. Athletic levels of fitness and large volumes of exercise are not necessary to produce significant reductions in health risk; moderate exercise can offer major health benefits.

Medical personnel should encourage sedentary and unfit individuals to increase their daily routine of energy expenditure. For many individuals, a formal exercise program is not practical or necessary. Simply decreasing sedentary activities and substituting moderate activities, such as walking and bicycling for recreation and transportation, may provide considerable health benefits. This would fulfill the exercise requirement of the major epidemiological studies reported earlier in this chapter. Increasing physical fitness levels in the U.S. population can make an important contribution to improving the nation's health (9).

Other Health Benefits of Walking and Bicycling

Other potentially beneficial, adaptive responses to exercise, in particular walking and bicycling, have been reported in the medical literature.

Weight Loss

The role of exercise in a weight-loss program is often underestimated. In addition to the calories expended during exercise, physical activity may contribute to a weight-loss program by decreasing appetite and increasing lean body weight. The most effective weight-loss programs combine both exercise and diet.

Walking is an appropriate exercise to prescribe as a component of a weight-loss program, and since it is a low-impact activity, there is low risk of injury. This applies particularly to obese individuals, who put tremendous stress on their skeletal and muscular systems in high-impact activities (10). The number of calories expended while walking is based upon body weight, pace,

and duration. Table 1 indicates the approximate number of calories burned for 1 mile at speeds of 3 to 4.5 mph for different body weights (11).

Table 1.

Walking Speed	**Body Weight (pounds)**					
(mph)	100	125	150	175	200	225
3.0	52	66	79	92	105	117
3.5	54	67	80	94	107	121
4.0	58	72	87	101	116	131
4.5	65	81	97	113	129	146

As with walking, several factors affect the caloric cost of bicycling. The most important aspect of bicycling energy cost is your speed of bicycling and frontal area. This is influenced by wind resistance, which is a major factor at bicycling speeds, but of no consequence at walking speeds. Maintaining 20 mph takes significantly more energy than going 17 mph. About 4 to 11 calories a minute are expended when bicycling at moderate speeds.

Table 2.

Caloric Cost of Cycling (Calories/minute)

Bicycling Speed (mph)	Calories/Minute
5.5	4.5
9.4	7.0
13.1	11.1

Mental Health

Once one enters an exercise program, there is often a reduction in depression and anxiety, and one begins to have an enhanced sense of well-being. A recent report showed that 40 minutes of walking significantly reduced the participant's tension and anxiety mood state (12).

A British Transport and Research Board survey established that individuals enjoyed bicycling because it gave them a sense of health, independence, and enjoyment and a means of transportation in spite of the dangers perceived in riding on the road. They also associated bicycling with economy, cleanliness, freedom, and "doing your own thing" (13).

Aging

Aerobic capacity declines with age. Regular exercise has been shown to ameliorate and, perhaps, prevent some of the chronic diseases that frequently surface in the elderly. Much of the decline in physical capacity can be slowed or even prevented by regular exercise.

Several studies reported in the medical literature have shown the benefits of increased physical activity in older Americans to be the same as those in younger individuals. In one study, four males and four females, between the ages of 35 to 53, participated in a 4-month walking program and increased their maximal oxygen capacity by 9.7 and 17.3 percent, respectively (14). In another study reported by Wilmore and co-workers, it was shown that a 20-week conditioning program of bicycling, jogging, and tennis showed that aerobic capacity increased comparably for jogging and cycling (14 percent), and tennis showed only moderate increases in endurance capacity (15). Ages of participants in the study ranged from 22 to 55 years, with the mean of 33.4 years.

Osteoporosis

Osteoporosis has considerable economic consequences in the United States, with over 1.5 million fractures each year at an annual cost of about $6 billion. Studies have shown the relative benefits of increased weight-bearing physical activity such as walking will stimulate bone content and slow its rate of loss. Walking is an excellent low-impact, weight-bearing activity that promotes bone growth. A study done at the University of Washington found that women with osteoporosis who walked 3 days per week, including walking upstairs and on a level surface, for 1-hour per day, increased bone density in the spine (and presumably in other parts of their body) by 6 percent over 9 months.

While bicycling is not primarily a weight-bearing activity, as the body is partially supported, there is some load on the bones while bicycling and especially during an uphill climb. In addition, there is increased muscular strength from regular bicycling and this will provide protection against fractures.

Cholesterol

Exercise has been shown to decrease the total level of cholesterol and increase the level of high-density lipoprotein (HDL), the "good" cholesterol in the blood. High levels of HDL cholesterol can help remove the cholesterol from the walls of the arteries and transport it to the liver where it can be metabolized.

A study comparing the number of miles walked per day was positively associated with HDL among mail carriers who did not engage in any other vigorous physical exercise (16). This work shows that regular walking may have an influence on blood cholesterol levels. Work by Thompson and others showed that stationary bicycling (five times per week for one hour at 80

percent of maximal heart rate for three months) caused a 13 percent increase in HDL cholesterol (17).

Hypertension

The American Heart Association reports that high blood pressure affects an estimated 23 percent of the American population. Controversy persists over the effects of aerobic exercise on persons with hypertension, but most evidence indicates that exercise is beneficial. The higher the blood pressure and less active the patient, the greater is the likelihood of blood pressure reduction to take place with exercise. For sedentary individuals, moderate activity is usually more beneficial than a strenuous exercise program. A program of walking and bicycling usually can be recommended by a physician before medication, unless the hypertension is severe.

Walking and bicycling reduce blood pressure indirectly by helping an individual lose weight, reduce stress, and quit smoking. In addition, these activities also help dilate the blood vessels and, thus, reduce the resistance on the walls of blood vessels. Exercise also reduces the production of insulin, which is known to increase blood pressure (18, 19).

Other Diseases

Low to moderate levels of exercise have also been shown to have positive health effects on diabetes, cancer, arthritis, and all causes of disease combined. Inactivity and low levels of physical activity and physical fitness are important risk factors for disease and early death, and are comparable in significance to other well-known risk factors such as cigarette smoking, high blood pressure, and cardiovascular disease.

Japanese Bicycle Study

In 1987, the Bicycle Association of Japan commissioned a study to investigate the health effects of bicycling. A nationwide research team composed of seven university professors has worked diligently on the project for three years.

The group's findings have recently been published by the chief research Professor, Junichiro Aoki of Juntendo University. The results of the study pointed out that bicycling is one of the most desirable aerobic exercises. As such, it is very effective exercise for persons with high blood pressure; it also increases HDL cholesterol, activates insulin for diabetics, strengthens the lungs, prevents age-oriented ailments, and strengthens the immune system so that colds and other maladies are light and cure quickly (20).

Economic Benefits from Enhanced Fitness and Health

Beneficial effects of physical activity may be noted at the level of the individual himself, industry and the government. Gains can be seen in lifestyle (reduction of appraised age, mood, improved health), in the workplace (greater productivity and reduced absenteeism, turnover, and injuries) and in the national health-care system (fewer physician visits, hospital care, and geriatric care). The United States would save billions of dollars if regular low to moderate exercise were adopted by the majority of our citizens.

Individual Benefits

Many surveys have affirmed that most individuals exercise to feel better. Other possible benefits of an active lifestyle are improved health, avoidance of chronic diseases, increased activity in sports, better family life, elevation of mood, extension of life span, and enhancement of personal appearance and self-image (21).

A physically fit person has a greater capacity to enjoy life than does someone who is less physically fit. A healthier pattern of eating (nutrition), along with a correction in alcohol and tobacco use will occur. Finally, there is some evidence that an individual's learning process is helped (21).

Corporate Benefits

The possible benefits of corporate-sponsored fitness programs, in addition to the employees' health status, include an upgraded corporate image, increased worker satisfaction, increased worker productivity, decreased absenteeism, lower employee turnover, and decreased injury rate.

Many companies now believe that the benefits of physical activity are sufficiently well established, and they are investing in corporate fitness/lifestyle programs. Some companies provide only showers at the workplace or subsidize membership in an external health club facility program. The annual cost of an onsite exercise facility is between $500 and $2,000 per participant. The elements of cost to be considered by the corporation include promotion, facilities, floor space, professional leadership, equipment, flexible hours, and safety considerations (22).

One common query concerns developing an exercise facility at the workplace, as opposed to subsidizing exercise of employees at another facility, or encouraging walking or bicycling to work. For this reason, activities that can be built into the normal day of an employee (for example, walking and bicycling to and from work or at lunch time) may prove more acceptable and more cost-effective than formal work-site classes. This saves money in health care costs and in the cost of commuting, and all that is required is the installation of shower, locker facility, and protected bicycle parking (23). In addition to increasing fitness and saving money, providing

these facilities and services will answer a key concern raised by participants in the 1990 and 1991 Harris Poll survey commissioned by *Bicycling Magazine* and Rodale Press.

National Benefits

The anticipated national benefits of increased participation in physical fitness include reductions in both the direct and indirect costs of illness and disease, improvement in lifestyle, and a reduction in geriatric costs.

The direct costs of perceived and real illness and disease include expenditures for physicians, hospital care, drugs, and nonpersonal items such as public health services, insurance, medical research, and training. Indirect costs also include loss time from work and premature death (24).

Total medical expenditures in the United States during 1929 were only $3.6 billion, or 3.5 percent of the Gross National Product (GNP). By 1960, national health expenditures totaled $26.9 billion, 5.2 percent of GNP. In 1985, $442.6 billion was spent on health care, 10.6 percent of the GNP. Annual health expenditures are expected to be considerably over $400 billion per year into the 1990's (25).

One-fourth of this medical bill is picked up by business through health insurance premiums. State, Federal, and local governments pick up most of the rest of the bill, which is indirectly passed on to each American. Illness and accident-related costs, including health, disability, and life insurance, workers' compensation, and sick leave, now constitute roughly 10 percent of payroll costs (26).

Healthy People 2000

According to "Healthy People 2000," a report on the national fitness released in 1990 by the U.S. Public Health Service with the input of 300 national organizations, State health departments, and others, low to moderate aerobic exercise such as walking and bicycling yields substantial health benefits (27). Even better, low to moderate exercise may be just as beneficial to your overall health as the breathless exercise we thought we had to endure for fitness.

Despite the surge in health clubs, adventure travel, exercise machines, and fitness books and the increase in awareness for "wellness," the fact remains that the fit among the population in the United States is a very small minority. According to the report, less than 10 percent of the U.S. adult population exercises for more than 20 minutes, 3 or more days per week, at 60 percent or more of cardiorespiratory capacity. Here are a few facts from "Healthy People 2000" that confirm many of the points stated several times in this report in earlier sections:

- Those who exercise regularly live longer than those who don't.

- Physically inactive people are more than twice as likely to develop coronary heart disease as those who exercise regularly.

- Regular exercise is now linked to a lower incidence of stroke and colon cancer, and may be linked to reduced back injuries, too.

- Regular exercise will not only enhance the quality of life as we age but help to maintain our functional independence also.

- Schoolchildren who exercise regularly enjoy better health and better grades.

Section 1.8 of the chapter on "Physical Activity and Fitness" gives the following recommendation for increasing leisure-time activity. Public education efforts need to address the specific barriers that inhibit the adoption of physical activity by different population groups. Older adults, for example, need information about safe walking routes, appropriate foot care and footwear for those with foot problems, appropriate levels of activity for those with coronary heart disease and other chronic conditions, and the availability of group activities in the community.

The report summarizes the need for a major shift to de-emphasize high-intensity exercise and focus instead on getting more people involved in moderate exercise. Walking and bicycling for recreation, transportation, and commuting will help the population of the United States reach these goals.

Summary

Evidence reviewed here strongly supports the beneficial impact of exercise and physical activity on various measures of functional capacity, disability, morbidity, and mortality. Although potential problems such as orthopedic injuries can be triggered in walking and accidents can occur in bicycling, evidence at present supports a favorable risk/benefit ratio for regular physical activity including such activities as walking and bicycling. Despite the improvements in recent years, most Americans are still sedentary; and large-scale public health intervention efforts are needed to further encourage regular exercise.

In this context, bicycling and walking offer numerous health benefits for the United States. Both activities not only improve the quality of life and individual health, but they also improve the health of others because of reduced air pollution, noise, and impact on the earth's environment. The use of walking and cycling to work, for utility travel, and for recreation may offer some benefit to national health standards and is a logical activity for continued emphasis and study.

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3. Environmental Factors Affecting Bicycling and Walking Use

The human being is extremely adaptable. We are capable of not only surviving in a variety of environments but of performing under the most extreme circumstances. We adapt to both short-term and long-term exposures to cold, heat, altitude, and urban life. We can even tolerate air, noise, and water pollution.

The physiological problems encountered in adverse environments affect all systems of the body, but the greatest influences are seen in the respiratory, cardiovascular, thermoregulatory, muscular, and neural systems. This chapter emphasizes both climatic and air pollution problems experienced by pedestrians and bicyclists while commuting and exercising. It will present information on the need for a reduction of motorized travel and an increased use of walking and bicycling. All this stands out in light of the current international environmental problems caused by increased motor vehicle use, coupled with increasing evidence that air pollution and noise pollution are a serious risk to the health of the nation.

Walking and bicycling, as means of transportation and recreation, are environmentally friendly, use very little natural resources, do not cause noise or air pollution, and do not cause major congestion. Motor vehicles, on the other hand, are the major consumer of the earth's energy resources, and are the major source of noise and air pollution in the United States.

But in spite of a growing concern over this trend, of the 80-plus million bicyclists, only about 3 million commute by bicycle to work on a regular basis, less than one percent of all commuters in the United States. Our economic competitors benefit from much higher levels of bicycle commuting. For example, in Germany 11 percent of the trips to work are by bicycle; in Japan, 15 percent; in the Netherlands, 30 percent; and in Switzerland, 10 percent.

Promoting walking and bicycling as a means of transportation is more than "just a good thing to do." The potential environmental, economic, and social benefits are quite large. Bicycle commuting saved the United States 17 million barrels of oil in 1990. If the recommendations of the 1980 Department of Transportation report, "Bicycle Transportation for Energy Conservation," had been implemented, as many as 200 million barrels of oil would have been conserved during the 1980's (1). That's enough to keep the entire United States driving to work for a month, at the cost of millions of dollars in imported oil (2).

Bicycling and walking are realistic solutions to today's pollution problems. Every new car, complying with every federal standard, emits over 100 pounds of pollutants every year. Just switching from a car to walking or bicycling can save up to 2.0 grams of hydrocarbons, 20 grams of carbon monoxide, and 1.6 grams of nitrogen oxides of every mile traveled.

Just how realistic is bicycle commuting for most people? More than half the population of the United States lives within 5 miles of the place they work, which requires less than 30 minutes of bicycling. Some individuals live within 1 or 2 miles and could walk to work. In addition, millions more live within easy riding or walking distance of efficient bus and train systems. If just 2 percent of the U.S. work force living within 2 miles of a transit route and commuting the full distance to work were to bicycle or walk to a mass transit facility, 120 million gallons of gasoline could be saved every year.

Riding or walking to a "park and ride lot" would save the average motorist 150 gallons a year, enough to cover the cost of a $200 bicycle. Some public agencies reimburse cyclists 10 cents per mile—about one-fourth of what they would have to pay to own and operate an agency automobile (2).

As we have discussed earlier in this case study, if walking or bicycling to work will improve the environment and improve one's health, then why don't more people do it? The answer lies in the fact that the majority of commuters want safer routes and better facilities at work to store bicycles and change clothes. But some cities are changing commuting standards. Cities such as Madison, Wisconsin, Gainesville, Florida, Boulder, Colorado, Eugene, Oregon, Davis, California, Minneapolis, Minnesota, and Arlington, Virginia, are actively promoting walking and bicycling programs and are providing safer environments for commuting. It is no wonder then that many surveys and magazines rank these cities high in the quality of life and physical environment.

These cities have promoted bicycling and walking and have changed the physical environment that can sustain increased bicycling and walking, for commuting and recreational purposes. With better road planning, increased bike routes being established, employee incentives instituted, and facilities planned for employees at the worksite, we would begin to see dramatic increases in pedestrian and bicycling transportation in the United States. Bicycling and walking to work are easy ways for most Americans to get in their daily exercise and help clean up the air.

Pollutants Produced by Transportation

In 1985, nationwide, motorized transportation resources were responsible for 70 percent of the carbon monoxide, 45 percent of the nitrogen dioxide, 34 percent of the hydrocarbon (HC), 18 percent of the particulate, and 73 percent of the lead emission in the environment (2). As a consequence of these increased emissions, in the United States, 146 million Americans (over 60

percent of the population) live in areas that do not meet air quality standards, and up to 30,000 premature deaths are estimated to be caused by air pollution from motor vehicles (3).

The major atmospheric pollutants arising from motor vehicle use that affect walkers, bicyclists, and the nation as a whole are described in the following paragraphs.

Ozone

Ozone, also known as smog, is produced in the environment by the photochemical reaction of hydrocarbons and nitrogen dioxide emissions, and is, therefore, the primary motor vehicle pollutant. Increased airway resistance is one effect associated with short-term exposure to high concentrations of ozone. The increased airway resistance causes an increased rate and decreased depth of breathing, which increases the energy cost of breathing and may also decrease maximum ventilation during walking and cycling.

Research has demonstrated a 10 percent reduction in the aerobic capacity of subjects breathing ozone at the levels comparable to peak levels observed in smog-prone cities (4). Long-term exposure to high levels of ozone has negative health implications; for instance, it can cause lung changes, such as obstruction of the bronchioles (5).

Carbon Monoxide

Carbon monoxide creates problems in the body because of its high affinity for the hemoglobin in red blood cells—210 times greater than that of oxygen. When a molecule of oxygen competes for the same hemoglobin attachment site, the carbon monoxide wins easily, leaving the oxygen behind. This is a potential penalty of the exercising body. At concentrations generally found in urban air, carbon monoxide can aggravate cardiovascular diseases and impair mental functions.

People who live in rural, traffic-free areas generally have blood carboxyhemoglobin (carbon monoxide combined with hemoglobin) concentrations of 0.5 percent, or about half the level observed in city dwellers who remain indoors. City dwellers who stand outside for 30 minutes amidst heavy traffic can increase their levels fivefold. Strenuous exercise in heavy traffic for 30 minutes can increase the level tenfold—the equivalent of smoking a pack of cigarettes (6, 7).

As we have seen, exhaust fumes from motor vehicles are the major contributor to carbon monoxide pollution. However, air quality is not necessarily better even when traffic is light; high concentrations of carbon monoxide can linger for hours, depending on wind conditions. In addition, shade trees can trap polluted air, raising concentrations to very high levels along walking and bicycling roads, paths, and lanes.

Nitrogen Oxides

Nitrogen oxides represent a number of compounds produced during combustion. These are a brownish gas with a pungent odor. The gas is a cause of the brownish color of the sky in many smoggy areas and is produced in fossil-fueled electrical power plants as well as motor vehicles. Nitrogen oxide is a pulmonary irritant and short exposure to it may cause increased susceptibility to acute respiratory diseases.

Particulates

As a category, it includes all solid particles and liquid droplets in the air, except pure water, and encompasses a wide variety of distinct substances. Transportation contributes to the production of particulate matter through diesel fuel exhaust, and includes substances such as unburned hydrocarbons, sulfur dioxide, and sulfuric acid. Recent research indicates that particulate emissions can cause respiratory cancer. Beyond their health effects, particulate matter can impair visibility (by absorbing and scattering light) and can cause corrosion of exposed materials.

Noise Pollution

Noise pollution can lead to increased stress and hearing-related health problems. There is also no doubt that this also lowers the quality of the walking and bicycling environment. Although there are no surveys published in the literature of changes of noise levels over the years, the tremendous increase in the number of large trucks and automobiles on the road probably has increased the level of noise nationwide. From 1960 to 1987, the number of privately owned vehicles alone increased from 61.4 million to 137.9 million in the United States. The replacement of motor vehicles with walking and bicycling would dramatically reduce the level of ambient noise in this country.

Air Filters/Masks

The quantity and quality of pollutants entering one's respiratory tract depend on the amount of time breathing the air, how close one walks or rides to traffic, and depth of breathing due to the intensity of effort. During exercising or commuting in areas of high pollution, walkers and bicyclists could be considered to be at greater risk than the general population.

With the use of certain protective face-masks, selected pollutants and air-borne materials can be filtered out of the air. There are primarily two types of filter masks used by bicyclists and walkers. An inexpensive model consists of a simple filter (usually an open-cell foam) that primarily traps particulates and dust. The second model, and one that will protect your lungs better, uses an activated carbon/charcoal filter that prevents nitrogen oxide, nitrogen dioxide, particulates, hydrocarbons, sulfur dioxide, and ozone from reaching the lungs.

It should be noted that none of the masks sold on the market today will filter out carbon monoxide. In addition, proper fit must be assured so that no air gets into the lungs from around the sides, and the filters should be cleaned or replaced on a regular basis.

Any bicyclist or pedestrian who commutes regularly on very congested routes or has trouble breathing should wear a charcoal-filtered mask or commute during nonpeak traffic hours. Although face masks are a recommended means of protection against pollution, it is obvious that reducing air pollution is the most appropriate and effective solution to the problem (8).

Climatic Influences on Biycling and Walking

Several surveys on deterrent factors to increased bicycle use indicate that bad weather influences the level of bicycle use in the United States. A survey in Boston indicated that bicycling activity falls off when air temperature is below 40 degrees fahrenheit (9). The Boston survey showed that at least 10 percent of the student cycling population uses their bikes 10 to 12 months per year, and 22 percent rode 7 to 9 months per year. Thus, many cyclists continue to ride during cold weather.

Precipitation (rain and snow) affects bicycling and walking and is more inhibiting than temperature. The City of Madison, Wisconsin, assumes for planning purposes that the bicycling will decrease substantially on days when precipitation is of a 2-hour duration or more, and when an inch of snow is on the ground. In Boston, rainfall of 0.10 inches within any given hour during the day was used as a cutoff point to estimate decrease in riding (9).

With proper clothing for protection against temperature, wind, rain, and sometimes snow, commuting and exercising in inclement weather can be extended. Caution must be taken during winter months, for freezing rain and snow on streets and walkways may affect riding and walking conditions.

The discomfort of bicycling or walking in hot and humid weather, due to overheating, is rare on short to moderate commutes to work. This is especially true if they are undertaken in the morning and evening hours and not during the heat of the day. Selection of shaded routes will also greatly reduce solar heat load during bicycling and walking (5).

Summary

Various approaches can be taken to evaluate the economic impact of air pollution on the United States. One could assign a monetary value to each adverse physical and physiological effect of pollution. Or, alternatively, one can determine how much society is willing to pay in order to avoid what are considered the harmful effects of air pollution. Clearly, transportation-related emissions can have harmful effects on human health, visibility, and vegetation. However,

because there are many uncertainties regarding the significance and severity of these effects, it is difficult to put a monetary value on them.

But one thing is certain. The replacement of vehicles with walking and bicycling would considerably reduce the level of air and noise pollution. This would also make a major contribution to the reduction in production of greenhouse gases, which is currently a major concern in the international political agenda (10).

Transportation, ecology, and economics are woven into our lifestyle and related to health and fitness. A partial solution to the above trends in vehicular use, environmental damage, and increased health concerns is self-propelled movement. Bicycling and walking commuting are not the complete answers to urban transportation in the United States, but can have a major impact on motor vehicle use. In the worst of climatic conditions, we can revert to public transportation, car pools, and the personal car. But with proper clothing and rain gear, bicycling and walking can be comfortable beyond the normal seasons of spring, summer, and fall. Employers can provide bicycle lockers, showers as low-cost employee benefits, and encouragement toward increased employee fitness. Lastly, urban planners can plan for safer, less congested bicycle routes, paths, and lanes for increased pedestrian and bicycling commuting and recreational use.

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4. Hazards and Injuries Associated with Bicycling and Walking

Walking and bicycling are prevalent forms of exercise, transportation, and entertainment for many people. Unfortunately, bicycling and walking can lead to injury. Most of the injuries are due to accidents and not from overuse injuries. Any promotion of the health aspects of both activities must be made in the context of the risks of being involved in an accident or of experiencing an injury. This chapter examines the pattern of accidents, when and where they occur, and how to prevent accidental injuries. Attention will also be brought to the overuse injuries experienced in walking and cycling.

Hazards Associated With Bicycling and Walking

Bicycling

Many of the surveys in this report mention the concern of many cyclists for their safety while bicycling on roads for recreation and commuting. The coexistence of cars and bicycles on busy streets causes confusion, frustration, and accidents, making it dangerous for people in cars and on bicycles, not to mention for pedestrians.

Bicyclists are in danger of injury because of their exposure to motor vehicles, the instability of the bicycle, and the contact surface on which they fall. Bicyclists often share the road with motor vehicles, which can lead to confrontations. Young or inexperienced bicyclists often are not physically coordinated enough to handle the speed and uncertainty of a bicycle. They may misinterpret traffic speed and movement. Careless motorists and bicyclists place the rider at significant risk when either ignore rules of the road. In addition, a bicyclist riding at high speed may be unable to hear nearby traffic because the wind blowing past the ears limits hearing.

The bicycle's stability is affected by the rider's speed, physical ability, passing motor vehicle traffic, wind, and road surface. The last factor is especially important for those riding in streets without bicycle lanes. A bicyclist can be thrown when the front wheel strikes an uneven road surface, such as a curb, gravel, litter, or storm drain.

The bicycle-related injuries that are treated in hospital emergency rooms each year are tracked by the Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS). During the past several years, the number of bicycle-related injuries treated in emergency rooms has decreased to a low of 514,700 in 1989. In 1990, the emergency room sample was updated, which made NEISS estimates an average of 18 percent higher across all product-related injury types. CPSC states that the 580,100 bicycle-related injury figure for 1990 is not comparable to previous years due to the way the data were collected. For example, in 1988 the CPSC reported that 525,000 individuals were treated in emergency rooms, and in 1989 the numbers recorded were 514,700. The 1990 statistics show the following:

- Less than 3.6 percent of the 580,100 bicyclists seen in emergency rooms last year were hospitalized. The other 96.4 percent were treated and released.

- Over two-thirds of the injured bicyclists seen were males.

- Two-thirds of those injured and treated were under 14 years of age.

The number of bicyclists killed each year as a result of bicycle-motor vehicle collision is compiled by the National Highway Traffic Safety Administration. A majority of all the bicyclist's injuries, such as those represented in the NEISS data, do not involve motor vehicles. However, approximately 90 percent of the bicyclist fatalities do involve a collision with a motor vehicle. In 1990, 856 bicyclists were killed. The National Highway Traffic Safety Administration figures show:

- Less than 2 percent of all traffic deaths involve bicyclists.

- The proportion of adult bicyclists killed has continued to grow each year. In 1977, 22 percent of those killed were adults of 21 years and older. In 1990, this increased to 54 percent. Slightly more than 70 percent of those killed were 15 years old and older.

- Across all age groups, males are much more likely to be killed. Nearly 86 percent of those killed in 1990 were male.

Responsibility for serious bicycle-motor vehicle crashes is related to age. Through age 12, most such crashes are found to be the responsibility of the rider; only about one-third of the bicyclists 25 and older are responsible for their crashes (1).

For a detailed analysis of bicycle accidents, a classical research study identifying basic bicycle accident types, causal factors, and target populations, was completed by Dr. Kenneth Cross in 1977. The study was limited to bicycle-motor vehicle accidents, since this type accounts for the greatest percentage of all serious and fatal injury accidents (2). Since this report, many education programs have been revamped to reflect some of the insights from the study.

Head Injuries and Bicycling

From the above data we can see that bicycling accidents cause a great burden upon our health care system. The most common cause of death and serious disability in bicycle accidents is head injury. A number of studies report that head injury is the primary or contributing cause of death in 70 to 80 percent of all bicycling fatalities (5, 6). One-third of all victims of bicycling accidents treated in emergency rooms have head injuries, as do two-thirds of all patients with bicycle injuries admitted to hospitals (7).

Head injury (both fatal and nonfatal) remains the most serious consequence of childhood bicycle riding, and such mishaps are the single most important cause of head injury in childhood (8). Most accidents are due to loss of control of the bicycle, usually involving unsafe riding practices, not using helmets, inattention, inexperience, and inability to respond to poor road conditions.

Walking

As with bicycling, motorized traffic is detrimental to the safety of pedestrians either while exercising or commuting. This can be seen in relation to the effect that motor vehicle travel has on the risk of physical injury in traffic accidents, and to the psychological impacts of distress and bereavement resulting from such accidents. But while motor vehicle accidents are not the major cause of deaths to bicyclists, they are the principal cause of mortality and morbidity in adults and children while walking (3).

Research reported by Dr. Mayer Hillman (4) of the Policies Research Institute in Great Britain shows that, other than motorcycling, walking and bicycling have the highest casualty rates per kilometer traveled. He reports that the fatality rate for walking is 18 times higher than that for car travel. Owing to their lack of protection, pedestrians and bicyclists are especially vulnerable to injury when they are involved in a road accident. When compared to other means of transportation, the death rate for pedestrians while walking is the highest, despite the low speed of walking, clearly from high involvement in accidents involving motor vehicles.

Overuse Injuries in Bicycling and Walking

The medical literature has provided us with extensive information about accidental trauma in bicycling. However, only limited attention has been paid to nontraumatic injuries of walkers and bicyclists.

Of the few reports on the topic in bicycling, knee pain, buttock pain, neck and back pain, and hand numbness are the most prevalent problems among bicyclists (9, 10). Most of these problems can be managed with proper positioning on the bicycle, use of protective clothing, and proper footwear.

Exercise modes using low-impact activities for training, such as walking, appear to produce significantly lower injury rates than high-impact activities, such as running (11, 12). As with bicycling, selection of equipment and technique are important for injury-free participation in walking. Selection of comfortable walking shoes and proper walking technique will prevent nontraumatic injuries.

Accident Prevention

Bicycling on roads requires the bicyclist to exercise increasing skill in "reading" the environment with its numerous signals and signs, while at the same time maintaining balance and control of the bicycle and keeping an eye on poorly maintained road surfaces. The higher the speeds of the bicyclist or motorist, the less time there is also available to take evasive action in the event of a possible collision. This poses a particular problem for children or adults who have not yet sufficiently developed their skills, and the elderly whose skills may be declining (4). The same holds true for the pedestrian who may have to react quickly to traffic patterns.

In examining the role of the individual exercising or commuting, it should be remembered that few individuals ride or walk into motor vehicles. Most fatal accidents occur as a result of being hit by a carelessly driven motor vehicle. Nevertheless, there are several ways individuals can counter some of the risk of injury or damage to their health while walking or bicycling.

Education

Since most accidents are due to poor judgment or riding errors on the bicycle, educational measures should be undertaken to improve judgment and eliminate errors. Walkers and bicyclists need to obey all traffic regulations, observe local ordinances, be extremely careful at intersections, protect themselves at night with lights and reflectors or reflective clothing, and ride a safe and properly maintained bicycle. Most of all, they should ride and walk defensively, watching out for carelessly driven vehicles. Children, in particular, should be required to learn good safety practices.

Bicycle Helmets

Bicycle helmet use has been effective in reducing morbidity and mortality from head injury caused by bicycle accidents. In a study published in 1989, Thompson, et. al., at Harborview Injury Prevention and Research Center in Seattle, Washington, found that bicyclists wearing helmets significantly reduced their risk of death and disability from head injury in bicycle accidents. Using a case control study technique, they concluded that helmet-wearing reduced the risk of head injury by 85 percent, and the risk of brain injury by 88 percent (5). In their study, 68 percent of severe head injuries occurred in bicyclists under the age of 15. They found that fewer than 5 percent of the under-15 age group wore helmets, in contrast to more than 20 percent of the adult riders.

Recently, data collected from the National Center for Health Statistics Multiple Cause-of-Death Public Use Data Tapes from 1984 to 1988, showed that bicycling accounted for 2,985 deaths from head injuries (62 percent of all deaths) and 905,752 head injuries. Forty-one percent of the head-injury deaths and 76 percent of the head injuries occurred among children less than 15 years of age. NCHS data show that universal use of bicycle helmets by all cyclists could have prevented as many as 2,500 deaths and 757,000 head injuries, i.e., one death every day and one head injury every 4 minutes. Their conclusions were for increased community-based education programs and legislated approaches for increasing bicycle helmet safety usage (7).

Wasserman and Buccini collected questionnaire data by mail from 191 recreational bicyclists who reported having fallen and struck their heads in a cycling mishap. Fifty-seven percent of the bicyclists were wearing helmets during the accident. Helmet-wearers experienced significantly fewer skull fractures (1 percent versus 11 percent) and facial soft tissue injuries (5 percent versus 18 percent) than those not wearing helmets (6).

In 1986, the Harborview Injury Prevention and Research Center undertook a project of parent education, reduction of helmet cost, and the use of sports heroes to encourage increased bicycle helmet use in the Seattle, Washington area. In the first 3 years of the project, youth helmet sales in the Seattle area rose from 1,500 to 22,000 and the observed helmet-usage rate among school-age children increased from 5 percent to 16 percent, compared with a rise of 1 to 3 percent in the control community (13).

Recently, the group reported that in 1991 bicycle helmet use among Seattle-area children stood at nearly 40 percent. In addition, now more than 56 percent of the adults wear bicycle helmets. Other results show that more than 90 percent of the children wear helmets when riding with adults who wear them; helmet use among adults did not vary according to socioeconomic status; and children were more likely to wear helmets on bicycle paths and adults more likely to wear them on streets (14).

Mandatory Helmet Laws

Several States or jurisdictions have passed various versions of required helmet-use laws. For example, Montgomery County, Maryland, requires bicyclists age 17 and under, whether a bicycle operator or passenger, to wear an approved helmet. In California, children under the age of 4 being carried as a passenger must wear an approved helmet. Recently, the State of New Jersey passed a law that made it illegal for a person under the age of 14 to ride a bicycle without a helmet. Several other States, counties, and cities have similar laws for children and adults as operators or passengers.

Helmet legislation may not be the total answer to reducing the incidence of death and severe head injuries in cycling. Education on why there is a need for helmet use may be more effective in increasing the use of bicycle helmets. Even a helmet will not substitute for knowing how to ride safely. The Harborview program shows that education can have a significant impact on helmet usage by children and adults. Mandatory helmet laws may deter many individuals

from riding their bicycles and make them turn to motor vehicles for transport. In Australia, where helmet laws were pioneered in the 1980s, emergency rooms report that bicyclist head injuries are down about 50 percent, but so is every kind of injury, which indicates a serious participant reduction.

Legislation may distract attention from more effective means of reducing the number and severity of accidents, such as reducing the speed of motor vehicles on certain roads, further separation of bicycles and motor vehicles, and increased rider education. Research needs to be undertaken to see if safer bicycling and walking networks, lower speed limits, educational programs, and changing the attitudes and behaviors of motorists, walkers, and bicyclists will reduce accidents and injuries to both bicyclists and walkers.

Use of Bicycle and Walking Paths and Lanes

Use of bicycle and walking paths, when possible, will remove an individual from most of the dangers of roadways. The addition of wide curb lanes or marked bicycle lanes to city streets may also allow for safer bicycling environments. In addition, proper maintenance of paths and streets, and the removal of loose gravel and sand, will add to the safety and security of bicyclists and increase the use of such facilities. Lastly, separate facilities keep children off public roadways.

But accidents do occur on paths, lanes, and on the roadway. Proper design, participant riding speed, and maintenance are key to injury reduction.

Lights, Reflectors, and Reflective Clothing

Although the use of lights and reflectors is mandatory for cycling in many localities, it is seldom enforced. Their use in walking is not mandatory. The increased use of lights, reflectors, and high-visibility clothing will alert a motorist to a bicyclist and a walker at a greater distance at night and, in most circumstances, they will give the individual a wider berth. A variety of high-powered halogen lights are now available for bicycling and walking, and battery-powered red lights and strobe lights can be attached to an individual's waistband so they may be seen by overtaking cars. As during the night, bright clothing worn during daylight hours will also increase motorist awareness of the bicyclist or walker.

While helmets are intended to reduce the incidence of head injuries in accidents, these safety aids are intended to give earlier warning of the presence of a bicyclist and, thereby, reduce the chances of, or prevent, collisions with other vehicles in the first place (4). They offer a more preventive approach to road safety than helmets.

Summary

There are many reasons to encourage the greater use of bicycles and walking. And as more people use these means of transportation, we need to respond to the growing concerns for safety. Bicycling and walking will not replace cars as the main form of personal transportation in the United States, but there should be efforts made to help those who wish to commute in a less expensive, environmentally friendly, and healthier manner. And as walking and bicycling injuries continue to occur and even increase, we now need to consider changes in safety and skill education, increase helmet use, and make the environment in which these activities are practiced less dangerous.

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5. Bicycling and Walking in Rehabilitation Settings

Injuries and certain chronic medical conditions heal at varying paces with rehabilitation, depending on their severity and location. If rehabilitation is to be complete, it is essential that whoever is treating the individual should have a thorough knowledge of the healing process in different tissues. They should also be thoroughly familiar with the physiological or orthopedic mechanisms of the body segment or organ that is being rehabilitated. Then the various elements of the rehabilitation program can be introduced appropriately to ensure a successful return to active exercise or work.

There are many medical conditions, injuries, and diseases that are treated and rehabilitated with exercise. In order to understand the connection between exercise, health, and rehabilitation, it is necessary to appreciate a fundamental law of nature called Wolff's Law. In the late 1800s a German physiologist, Julius Wolff, showed that changes in the function of bones (and other body tissues) that are injured will rebuild according to the stress placed on them. This became known as Wolff's Law and is an example of the general principle that tissues of the body respond and adapt themselves to the stresses imposed on them. Conversely, if the tissues of the body are deprived of normal function and normal stresses, then they will cease to develop and will eventually wither, a condition known as disuse atrophy (1).

No longer does rehabilitation wait until the injured part is "healed"; rather, rehabilitation is started while healing is taking place, resulting in an earlier return to activity and perhaps an improvement in the quality of the tissues that form during the healing process, or a further degeneration of the injured or diseased system.

Bicycling and walking are key exercises that are used as modes of exercise and rehabilitation for individuals with certain diseases and injuries. Bicycling and walking offer adequate stimulus for bone growth, can strengthen the heart muscle, and are easier on the joints for people with various disabilities.

Arthritis

Arthritis is really a collection of more than 100 different diseases that cause inflammation and pain in joints. Osteoarthritis is the most common and happens to all joints of use with age.

Osteoarthritis is a fraying of the bone and a depletion of the cartilage that leaves two bone ends rubbing together. It is known as a "wear and tear disease" because unusual usage or overuse seems to bring it on (normal usage does not, however). For example, ballet dancers often develop arthritis of the feet, baseball pitchers in the shoulder, and soccer players in their hips.

Although osteoarthritis is the most common, other types, such as juvenile (strikes those under the age of 18) and rheumatoid arthritis afflict millions of Americans. These are referred to as systemic diseases, meaning that they usually travel throughout the body and attack several joints at once. The causes of these types of arthritis are unknown, although a virus is suspected.

Bicyclists and walkers, as a rule, will not develop osteoarthritis because the joints are exercised evenly and in a low-impact fashion. In addition, underuse of the joints in arthritis patients can increase the severity of the problem. Joints do not have their own blood supply. The only way joints can get rid of wastes and get nutrients is through movement. Walking and bicycling exercises the entire body, and can aid in preventing the disease or stopping further joint damage (2).

Most individuals with arthritis can bicycle or walk daily. Exercise will strengthen the whole body and increase one's stamina. However, during a flare-up of a joint, active exercise should be avoided in that joint. But with proper medical guidance and supervision, modified exercise may still be advised. For example, those who suffer from arthritis of the hip joints usually retain flexion movement even when the disease is advanced or there is a major flare-up. Bicycling may, therefore, be an ideal way for these individuals to get around with minimal discomfort in commuting or exercising.

Other forms of systemic arthritis that are similar in nature such as gout, lupus, and multiple sclerosis (which destroys the central nervous system) and Parkinson's disease (destroys nerve centers and neurotransmitters) respond to walking and bicycling, as does arthritis. Patients with these diseases are using walking (and bicycling when possible) to train the muscles and to regain lost motor skills.

Findings from studies of patients with either rheumatoid or osteoarthritis, who participate in an aerobic exercise program, show that the patients make significant gains in aerobic capacity, functional status, muscle strength, and other aspects of performance. In addition, they improved in subjective aspects that might have a positive impact on quality of life, including pain tolerance, joint pain, mood, and social activity (3, 4).

Several well-controlled studies with rheumatoid and osteoarthritis patients, engaged in a graded-progressive exercise program of bicycling and resistive training, have shown positive results. The number of swollen joints decreased 35 percent and the patients' strength and aerobic capacity increased in one study. The exercised patients described improvement in activities of daily living, reduced joint pain, and fatigue.

The biomechanics of bicycling and walking, compared with other forms of exercise, will ensure that patients will continue with an exercise program with lower risk of discomfort and injury.

Cardiovascular Rehabilitation

Cardiovascular rehabilitation used to underestimate the need for exercise and lifestyle changes. If individuals survived the heart attack, their options were to go home, rest, and take medication, or to submit to bypass surgery, then go home, rest and take medication. Now an important aspect to prevention and rehabilitation includes major changes in lifestyle and nutritional practices, weight loss, and exercise.

In 1924, Dr. Paul Dudley White of the Massachusetts General Hospital, the father of American cardiology and founder of the American Heart Association, dramatically changed the treatment of heart attacks. In the early 1920s he began to tell the medical community that they should encourage individuals to participate in daily exercise. He knew from his own life that walking and bicycling made him feel better. Based on his own experience, he knew that exercise was not dangerous, but that it was beneficial.

Not until the 1950s did his ideas start to change the way doctors handled individuals with heart disease and heart attacks. As we have seen, patients would spend five to six weeks in the hospital flat on their back so that the heart could heal. During that period it was believed that the heart was healing and a "scar" was needed to form over the wound. But Dr. White and his fellow cardiologist, Samuel Levine, both began to dispute the bed-rest theory. They saw too many complications from this procedure: pulmonary and blood clots, and urinary tract infections. They decided that the human body was designed for activity, and would heal faster in the process. They showed that exercise such as walking and bicycling could be powerful medicine in treating the cardiac patient.

Walking and bicycling have become important exercise modes in cardiac rehabilitation. Outpatient programs put emphasis on dynamic and rhythmical exercise that does not impede normal breathing. Outdoor walking and bicycling (and indoor stationary bicycling) make excellent forms of exercise for outpatient phase II and III community-based programs (various stages in cardiac rehabilitation, outside the hospital) because one can control intensity and work-output. In general, walking and bicycling for the cardiac patient can begin early in the rehabilitation program and should progress slowly. Riding and walking should be at a low intensity, emphasizing greater frequency and longer duration, be individualized, and help the patient return to a normal life (5). Walking and bicycling can improve compliance and reduce program dropout rate by providing an outdoor, sociable exercise activity (6). The natural history of cardiovascular disease may be beneficially altered by walking and cycling in conjunction with standard risk factor reduction measures.

Knee Rehabilitation

The knee is the most-injured joint in the body. Among the activities that contribute to the prevalence of these injuries are skiing, tennis, football, and running. Walking and cycling are excellent forms of exercise for knee-injured patients. As rehabilitation forms of exercise, walking and bicycling do not have the impact of some other activities that involve running, high impact, or quick movements. The forces placed upon the knee are much lower in walking than many other activities. Secondly, walking and bicycling can strengthen the muscles that support the knee, and lead to a stronger joint after rehabilitation (2).

How does bicycling and walking help? Mostly by eliminating the pounding your knees take during foot strike. In walking, this can also be aided by walking on level ground, on dirt, or grass, and by selecting proper footwear. Bicycling does involve both a pushing and pulling on the knee, but the transition between them is always smooth, never giving it a jolt. Avoid high gears and pedal at 70 to 100 rpms while on the bicycle to avoid stress on the knees.

In addition, bicycling provides safe tracting of the knee in rehabilitation. With your feet held in position by toe clips or clipless pedals, the knee stays in the same position with each pedal stroke. And shifting gears allows one to control the amount of force applied to the knees.

Thus, cycling and walking allow an individual to maintain cardiovascular fitness while at the same time helping heal the injured knee. The controlled, nonstressful exercise of the knee while walking and bicycling maintains muscle tone and circulation around the knee without risking further injury (7, 8).

Summary

The musculoskeletal system of the body contains more than 200 bones, hundreds of muscles, ligaments, and tendons and is very susceptible to injuries and disease. By the age of 40 to 50, many individuals are showing signs of joint deterioration (osteoarthritis) or are struck by disease (rheumatoid arthritis), or are injured in an accident or in sports participation.

A regular program of walking and bicycling can be effective in battling the aging process, or aid in the rehabilitation of injuries or disease. Walking and bicycling are gentle, nonjarring activities that promote joint and bone density, build muscles, and counteract the slow degeneration of the musculoskeletal system. Moreover, while bicycling and walking cannot prevent diseases such as multiple sclerosis, various forms of arthritis, and Parkinson's disease, they can serve as major forms of rehabilitative exercise.

Cardiovascular disease is the number-one killer in the United States. More than 1.25 million individuals experience a heart attack each year. Along with lifestyle changes, stopping

smoking, and diet, walking and bicycling can be used to strengthen the heart, reduce stress, change unhealthy habits, and reduce the risk of another heart attack.

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