58. Lichtman, S., and Poser, E. G.: The effects of exercise on mood and cognitive functioning. J Psychosom Res 27: 43–52 (1983).
59. Gutin, B.: Effects of increase in physical fitness on mental ability following physical and mental stress. Res Q 37: 211–220 (1966).
60. Butler, K. N.: The effect of physical conditioning and exertion on the performance of a simple mental task. J Sports Med Phys Fitness 9: 236–240 (1969).
61. Davey, C. P.: Physical exertion and mental performance. Ergonomics 16: 595–599 (1973).
62. Crews, T. R.: The influence of exhaustive exercise on reaction time of conditioned adult males. Am Correct Ther J 33: 127–130 (1979).
63. Barry, A. J., Steinmetz, O. R., Page, H. F., and Rodahl, K.: The effects of physical conditioning on older individuals: II. Motor performance and cognitive function. J Gerontol 21: 192–198 (1966).
64. Statistics Canada: Culture statistics/recreational activities 1976. Catalogue No. 87-501, occasional. Minister of Supply and Services Canada, Ottawa, 1980.
65. Canada Fitness Survey: Fitness and lifestyle in Canada. Fitness Canada, Ottawa, 1983.
66. National Center for Health Statistics: Highlights from wave I of the national survey of personal health practices and consequences: United States, 1979. Vital and Health Statistics, Series 15, No. 1. Hyattsville, MD, June 1981.
67. National Center for Health Statistics: Exercise and participation in sports among persons 20 years of age and over, United States, 1975. Advancedata, No. 19. Hyattsville, MD, 1978.
68. Blumenthal, J. A., Williams, R. S., Williams, R. B., and Wallace, A. G.: Effects of exercise on the Type A (coronary prone) behavior pattern. Psychosom Med 42: 289–296 (1980).
69. Gillespie, W. J., et al.: Changes in selected psychophysiological indicators of coronary risk in male corporate executives as a result of an aerobic exercise program (abstract). Med Sci Sports Exerc 14: 116 (1982).
70. Rejeski, W. J., Morley, D., and Miller, H. S.: The Jenkins activity survey: exploring its relationship with compliance to exercise prescription and MET gain within a cardiac rehabilitation setting. J Cardiac Rehabil 4: 90–94 (1984).
71. Jasnoski, M. L., Holmes, D. S., Solomon, S., and Aguiar, C.: Influence of initial aerobic fitness, aerobic training and changes in aerobic fitness on personality functioning. J Psychosom Res 25: 553–556 (1982).
72. Jasnoski, M. L., Holmes, D. S., Solomon, S., and Aguiar, C.: Exercise, changes in aerobic capacity, and changes in self-perceptions: an experimental investigation. J Res Pers 15: 460–466 (1981).
73. Cantor, J. R., Zillman, D., and Day, K. D.: Relationships between cardiorespiratory fitness and physiological responses to films. Percept Mot Skills 46: 1123–1130 (1978).
74. Sinyor, D., et al.: Aerobic fitness level and reactivity to psychosocial stress: physiological, biochemical, and subjective measures. Psychosom Med 45: 205–217 (1983).
75. Zimmerman, J. D., and Fulton, M.: Aerobic fitness and emotional arousal: a critical attempt at replication. Psychol Rep 48: 911–918 (1981).
76. Keller, S.: Physical fitness hastens recovery from psychological stress (abstract). Med Sci Sports Exerc 12: 118–119 (1980).
77. Sime, W. E.: A comparison of exercise and meditation in reducing psychological response to stress (abstract). Med Sci Sports 9: 55 (1977).
78. Morgan, W. P.: Negative addiction in runners. Physician Sportsmed 7: 57–70 (1979).
79. Little, J. C.: Neurotic illness in fitness fanatics. Psychiatric Ann 9: 55–56 (1979).
80. Yates, A., Leehey, K., and Shisslak, C. M.: Running—an analogue of anorexia? N Engl J Med 308: 251–255 (1983).
81. Thaxton, L.: Physiological and psychological effects of short-term exercise addiction on habitual runners. J Sport Psychol 4: 73–80 (1982).
82. Kron, L., et al.: Hyperactivity in anorexia nervosa: a fundamental clinical feature. Comp Psychiatry 19: 433–440 (1978).

Physical Activity and Exercise To Achieve Health-Related Physical Fitness Components

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Synopsis

To improve health and fitness effectively through physical activity or exercise, we need to understand how this comes about. For many of these changes, the stimulus has been grossly defined in terms of type, intensity, duration, and frequency of exercise, but for others a dose-response relationship has not been determined.

Physical activity that appears to provide the most diverse health benefits consists of dynamic, rhythmical contractions of large muscles that transport

the body over distance or against gravity at a moderate intensity relative to capacity for extended periods of time during which 200 to 400 kilocalories (or 4 kilocalories per kilogram of body weight) are expended.

For optimal health benefits, such activity should be performed daily or at least every other day and should be supplemented with some heavy resistance and flexibility exercises. The greatest benefits are achieved when the least active individuals become moderately active; much less benefit is apparent when the already active individual becomes extremely active. Overexertion or inappropriate exercise can produce significant health risks. Research is needed to characterize better the health-promoting features of physical activity and exercise.

THAT PHYSICALLY ACTIVE PEOPLE OF ALL AGES generally tend to be healthier than their sedentary counterparts has become a basic tenet of most health promotion programs in the United States. The health benefits ascribed to physical activity are varied and include enhancement of both biologic and psychologic functions (*1,2*). Whereas definitive evidence of a cause-and-effect relationship between an increase in habitual physical activity or exercise and many specific health benefits is still lacking, there is sufficient evidence of a positive relationship to warrant advising a physically active lifestyle in conjunction with other positive health behaviors. At the same time, we need to continue to advocate research into the characteristics of physical activity or exercise required to improve health and strategies to promote adoption and maintenance of physical activity.

Of critical importance to the design of an effective and safe physical activity program is a comprehensive understanding of the characteristics of the physical activity stimulus needed to develop and maintain the desired benefits. What type, intensity, duration, and frequency of exercise are needed to produce the targeted effect? Is there an absolute threshold of intensity, amount, or duration that has to be achieved, or does any increase produce some benefit? Is the exercise stimulus required to maintain fitness similar to that required to improve fitness? Can the physical activity be separated into small multiple bouts each day, or does it need to be performed in a more extended exercise session of 20 minutes or more? Is the dose-response relationship different for each health benefit? Are the exercise characteristics needed to improve health similar for males and females and for all groups of people? Since many people would prefer not to have to exercise vigorously to maintain good health, what is the minimum amount of exercise needed to improve health status? For most health benefits frequently attributed to exercise, we do not have the scientific data needed to answer precisely all of these questions.

Physical Fitness Versus Health

Improvements in physical fitness, especially cardiovascular endurance, frequently are equated with improvements in health status or disease prevention. The difference between health and fitness often is a difficult but an important distinction to make when attempting to define the physical activity characteristics necessary for improving health. A high level of physical fitness usually is associated with good health, but an improvement in fitness does not necessarily ensure an increase in resistance to disease or its consequences. For example, patients with disorders such as emphysema or schizophrenia can significantly increase their physical fitness through exercise without necessarily changing the severity of their disease or their medical prognosis. Becoming more physically fit and improving health status are interrelated, but they are not synonymous.

Physical activity may improve physical fitness (or one of its components) and clinical health status at the same time, but the improvement in health may be due to biologic changes different than those responsible for the improvement in physical fitness. For example, endurance training will increase aerobic capacity and may reduce the risk of coronary heart disease, but the biologic changes produced by the exercise responsible for these two benefits *may* not be the same: the increase in aerobic capacity is likely due to an increase in oxygen transport and utilization capacity, while a reduction in coronary heart disease risk may be the result of alterations in lipoprotein metabolism or fibrinolytic mechanisms such as blood-clotting. Therefore, while the improvement in physical

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fitness and health may occur simultaneously during physical activity, the exercise–induced stimulus needed for each might be quite different.

Sources of information. Information relating physical activity to health status comes from a variety of different types of research or practical experience. A majority of the studies that contain data concerning the effect of physical exercise on disease prevention are characterized by their observational nature: the clinical health status of physically active people is compared to less active people (cross-sectional), or the development of disease is analyzed according to baseline physical activity status (longitudinal).

Very few controlled, experimental trials have been completed that have adequately investigated the impact of an increase in physical activity on the primary or secondary prevention of a specific disease. Available data on the relationship of physical activity to the primary prevention of such disorders as coronary heart disease, hypertension, stroke, diabetes, orthopedic complications, or psychologic dysfunction are from observational and not experimental studies. Most studies have related lower risks for these disorders to activity status and not to level of fitness. Such data limit our ability to assess cause-and-effect relationships between physical activity and disease prevention and, in many cases, have not provided much precise information on the characteristics of the physical activity associated with reduced occurrence of disese. Much more evidence exists that exercise causes an improvement in the clinical status of patients or aids in secondary prevention (*3,4*).

Much of the data used to support the physical activity and health improvement hypothesis have been derived from studies that have investigated the effects of exercise on specific biologic changes known or thought to be linked either directly or indirectly to health status. These changes include measures of physical fitness (aerobic capacity, skeletal muscle strength, flexibility, and so forth) or biologic changes not necessarily linked to improved functional capacity (altered lipoprotein profiles, increased insulin sensitivity, delayed loss of bone calcium). While one cannot assume that a positive change in one of these biologic functions is the same as improving health status, these studies have contributed substantially to our belief that exercise improves health and to our knowledge regarding the characteristics of the exercise required to produce specific effects.

The stimuli needed. What has to occur as a result of physical activity so that the desired changes in health are produced? If physical activity is beneficial, there is some unknown response in the person triggered by the activity that subsequently causes the health benefit. We call this unknown the stimulus.

Is the effect acute (during or immediately after a single bout of exercise) or is it chronic (a delayed response only resulting after repeated bouts of exercise have been performed)? Is the stimulus for any specific health effect mechanical, chemical, situational, social, or some combination of these? While we know a great deal about how to describe many of the various exercise training effects, we know very little about their controlling mechanisms or the stimuli required to produce or maintain them.

The chronic effects of exercise (the training response) are adaptive responses by the body to the stress placed on various tissues and biologic functions by the increased metabolic, or physical, or mechanical demands (or both) of the exercise. If the appropriate type of exercise is performed at the proper intensity, duration, and frequency, sedentary persons of all ages will achieve significant improvements in physical fitness and associated health benefits. Thus, for exercise to produce a training response, it must provide a stress or demand on the appropriate function or tissue; and for improvement to continue, this demand must slowly increase over days, weeks, or months. This process follows three basic principles of exercise training: overload, specificity, and progression (*5*).

For some health benefits, such as improved fat and carbohydrate metabolism or increased insulin sensitivity, the necessary exercise stimulus appears to be similar to that required for the improvement in aerobic capacity: a sustained increase in the rate of energy expenditure by large skeletal muscles (*4,6*). The increased energy production during and following exercise increases the rate of functioning of other biologic systems needed to support the raised metabolic rate of the muscles and, if repeatedly stimulated, will increase their capacity or efficiency. It is the adaptive response of these other systems, including the central nervous system, that appears to provide many of the physical health benefits of exercise. However, it is not yet clear whether it is solely the repeated acute effects of the physical activity or a chronic training effect that produces some of the health-related benefits ascribed to aerobic training.

Stimuli may be related to the physical or mechanical stress placed on the muscles, connective tissue, or skeleton. For instance, the maintenance of muscle tone and good posture in children (*7*) and the retention of bone calcium through exercise following menopause (*8*), most likely are the result of mechanical stress placed on muscles and bones by weight-bearing or resistive physical activity.

We know very little about the required stimuli for the various psychological benefits ascribed to physical activity. Are the effects due to biologic changes resulting from the physical activity itself? Are they behavioral due to the interaction between the exerciser and the exercising situation, or to some combination of both biologic and behavioral factors? Do some of the beneficial psychological effects require strictly a biologic stimulus such as an alteration in sympathetic nervous system activity, whereas others are dependent on a behavioral stimulus such as physical separation from the stress-producing situation or the interaction with an exercise leader? From what little is known about these issues, it appears that multiple stimuli probably exist. As Bahre and Morgan (*9*) have pointed out, exercise may be a useful stress–coping mechanism for some people simply because it is "time out."

Leisure-time activity can be an effective way of physically and mentally separating oneself from stress-producing situations at home or work. The physical separation plus pleasant surroundings, an enthusiastic exercise leader, and sympathetic co-exercisers may be all that is required to decrease anxiety, hostility, or depression; the actual exercise and its biologic effects may be secondary. Added to these possibilities are the diversionary effects of competition with oneself to do better, or with others to do well or win, and the stimulus of excitement or risk of some activities.

Supplementing the situational or behavioral stimuli for enhanced psychological status may be biologic changes such as altered central nervous or hormonal regulation (*10*), improved exercise capacity, and changes in appearance. If individuals can work harder and longer at a task before they become fatigued or if they perceive that their appearance has improved, their self-image or general feeling of well-being may be improved.

'A physical activity plan for adults should consist predominantly (more than 75 percent of the time) of endurance activities performed frequently (three times per week or more) at a moderate intensity (50 percent to 75 percent of aerobic capacity). Ideally, activities should be selected that are convenient and enjoyable to perform.'

Physical activity requirements. The increase in estimated or measured aerobic capacity ($\dot{V}O_2$Max) has been commonly used to evaluate the health-promoting effectiveness of physical activity or exercise training regimens. If maximal oxygen consumption ($\dot{V}O_2$Max) or another measure of endurance capacity does not significantly increase, there has been a strong tendency to consider the exercise or activity regimen as not having beneficial health effects (*11*).

While enhanced aerobic capacity is closely tied to various beneficial hemodynamic and metabolic changes produced by exercise, many biologic and psychologic benefits can occur as a result of exercise or activity regimens that do not increase $\dot{V}O_2$Max or endurance capacity. For example, strength training may improve psychological status (reduce stress, improve self-image, and so forth) or help retain bone mineral content; low-intensity dynamic activity (less than 60 percent $\dot{V}O_2$Max) can reduce stress, contribute to weight loss, or improve selected biochemical reactions; and flexibility exercises may contribute to better musculoskeletal integrity with increasing age (table 1). Thus, it is very important to consider the specific objectives of the individual and his or her exercise capacity (recent exercise habits, age, clinical status), interests, skills, and opportunities when deciding on an exercise regimen.

Table 1. A physical activity plan for improving health and fitness in specific age groups

Major health-fitness goals	Physical activity plan[1]
Youth (1–14 years)	
• Optimal physical growth and development • Good psychological adjustment • Develop interest and skills for active lifestyle as adult • Reduction of CHD[2] risk factors	T Emphasis on large muscle, dynamic exercise; moving body over distance and against gravity; some heavy resistive activity and flexibility exercise I Moderate to vigorous intensity D Total of more than 30 minutes per day in 1 or more sessions F Every day G Increased activity to and from school
Young adults (15–24 years)	
• Optimal physical growth and development • Good psychological adjustment • Reduction of CHD risk factors • Develop interest and skills for active lifestyle as adult	T Emphasis on large muscle, dynamic strength and flexibility exercise I Moderate to vigorous intensity (more than 50 percent $\dot{V}O_2Max$) D Total of more than 30 minutes per session (more than 4 kilocalories per Kg of body weight) F At least every other day G Increased activity to and from school
Adults (25–65 years)	
• Prevention and treatment of CHD • Prevention and treatment of Type II diabetes • Maintenance of optimal body composition • Enhance psychological status • Retain musculoskeletal integrity	T Emphasis on large muscle dynamic exercise; some heavy resistive and flexibility exercises I Moderate intensity (more than 50 percent $\dot{V}O_2Max$) D Total of more than 30 minutes per session (more than 4 kilocalories per Kg of body weight) F At least every other day G Lower level activities (e.g. walking) every day
Older adults (over 65 years)	
• Maintain general functional capacity • Retain musculoskeletal integrity • Enhance psychological status • Prevent and treat CHD and Type II diabetes	T Emphasis on moving about, flexibility, and some resistive exercises I Moderate intensity (overload with slow progression) D Based on capacity of individual, up to 60 minutes per day in multiple sessions F Every day G Lower level activities (for example, walking) every day

[1] T = type of exercise; I = Intensity; D = duration or amount; F = frequency of exercise session; G = goal.

[2] Coronary heart disease.

Extreme inactivity or immobilization produces a number of major negative health consequences. These effects occur rapidly and are caused both by the supine posture as well as the lack of movement. Included in these changes are orthostatic intolerance (*12*), a negative nitrogen balance (*13*), increased calcium excretion (*14*), altered lipid metabolism (*15*), and skeletal muscle atrophy (*16*). These changes are closely linked to a reduction in health-related fitness but are rapidly reversible with ambulation (*17*). It is important, however, not to conclude from these data that similar health improvements will be produced when individuals go from a sedentary but ambulatory lifestyle to a more vigorous one (*18*).

Children (1 to 14 years). The desired health benefits of physical activity in children have primarily been on optimal physical growth and development, psychological well-being, including academic achievement, and the development of appropriate exercise skills and habits as a foundation for an active lifestyle as an adult. Some chronic degenerative diseases, like coronary heart disease, the clinical manifestations of which occur in adults, are considered to have their roots in childhood. Therefore, efforts have been made to determine the influence of exercise on risk factors or precursors for these diseases in children and to create an environment that fosters lifetime participation in active sports, games, or other vigorous leisure-time activities.

As in other circumstances, extreme inactivity in children (bedrest, or confinement for example) has negative health consequences including inadequate bone development or loss of strength, skeletal muscle atrophy, and cardiovascular deconditioning. A cause-and-effect relationship between activity level and psychological status has been difficult to demonstrate in children (*19*). Furthermore, it has not been possible from available data to determine if participation in structured exercise programs improves academic achievement. No convincing data exist to show that extremely active children (particularly participants in organized sports) are any healthier than children who perform moderate activity of various types on a regular basis.

Most evaluations of the health benefits of exercise in children have been made by comparing the health or growth status of those participating in structured programs of exercise (usually classes or teams) with those of children that do not (*20*). Such studies provide little information on the specific characteristics of exercise that provide health benefits at a younger age. In general, large-muscle, dynamic, weight–bearing activity performed at moderate to vigorous intensity appears to provide many health-related fitness benefits (*21*). Added to this activity should be flexibility exercises for the lower back, legs, and shoulders as good range of motion contributes to reduced orthopedic complications in later life. The activities that most children seem to like to do (running, jumping, climbing, pushing and pulling, cycling, or swimming) contribute to increased health-related physical fitness.

A few systematic attempts have been made to determine the effects of endurance training on coronary heart disease risk factors in children. In most cases little effect has been observed on either blood pressure or plasma lipid profiles (*22,23*). These results are not surprising given the relatively short training periods evaluated and the generally negative results of similar exercise training studies in adults when they have "normal" lipid or blood pressure values at baseline. Dose–response relationships have not been reported in any of these studies.

Young adults (15 to 24 years). The health benefits ascribed to physical activity or exercise training for young adults are similar to the claims made for children. According to much of the physical fitness literature, active young adults show more optimal physical growth and development patterns, tend to be better adjusted emotionally, and have better academic records. Again, many of these claims are based on cross–sectional studies comparing students enrolled in physical education or special physical fitness classes with other students and do not adequately account for self–selection factors (*24*). In some longitudinal studies with control groups, researchers have studied the effect of regular exercise on psychological adjustment and have obtained positive results (*25*).

College students have been the subjects most frequently used to investigate the exercise characteristics needed to produce health-related fitness changes as well as coronary heart disease risk factors. In fact, healthy men in their early twenties have become the "reference" population against which health-related fitness changes in other age and sex groups are frequently compared. Young men have been studied most often because they are available to investigators, they are at less risk than older adults, they tend to possess fewer characteristics that confound the interpretation of exercise training results (for example, cyclic hormonal changes, symptomatic chronic diseases or orthopedic complications aggravated by exercise), and because they are able and willing to perform relatively high-intensity training.

The idea that endurance exercise needed to be performed at 60 percent or greater aerobic capacity for beneficial changes to occur came from a short-term exercise training study on young men (*26*). This notion became popular rapidly, and many exercise training recommendations followed (*27,28*). However, several studies that have investigated slightly lower intensities of exercise training (approximately 50 to 60 percent of aerobic capacity) have found significant increases in aerobic capacity and selected hemodynamic or metabolic variables (*29,30*). It appears that it may take a longer time for lower intensity exercise to produce results somewhat similar to those frequently observed with higher intensity aerobic training (*30*). However, this alternative might be quite desirable if we are advocating a permanent change to a more active lifestyle, since the lower intensity is more acceptable to a larger portion of our target population and the medical risks are substantially less.

The cross-sectional comparisons of extremely active endurance–trained athletes with sedentary controls have provided a great deal of support for the contention that selected coronary heart disease risk factors are lower in people who are more active. Athletes who undergo endurance training consistently have more healthy looking plasma lipoprotein profiles (*6*), have body weights close to ideal (*31*) and increased insulin sensitivity (*4*). It has not been so easy, however, to produce such changes by getting sedentary young men or women to exercise (*32,33*). When these health-related fitness changes do occur, they are most likely produced by endurance exercise performed at moderate intensity for 30 minutes or more per session at least three times per week (*34,35*). A recent report suggests that weight training may produce similar effects, but the

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Table 2. Cause-specific death rates per 10,000 man-years of observation among 16,936 Harvard alumni, 1962-78, by physical activity Index[1]

Cause of death	Physical Activity Index, Kcal per wk <500	500-1,999	2,000+	One-Tail test for trend, P
All causes (N = 1,413)	84.8	66.0	62.1	<.001
Total cardiovascular diseases (N = 840)	39.5	30.8	21.4	<.001
Coronary heart disease (N = 441)	25.7	21.2	16.4	.002
Stroke (N = 103)	6.5	5.2	2.4	.001
Total respiratory diseases (N = 60)	6.0	3.2	1.5	.001
Total cancers (N = 446)	25.7	19.2	19.0	.026
Lung (N = 89)	6.2	3.7	4.0	.116
Colorectal (N = 58)	2.2	2.3	3.5	[2].091
Pancreas (N = 41)	1.8	2.4	1.0	.085
Prostate (N = 36)	2.2	1.5	1.8	.359
Total unnatural causes (N = 146)	8.7	7.1	6.9	.032
Accidents (N = 78)	3.6	3.9	3.0	.147
Suicides (N = 68)	5.1	3.2	2.9	.049

[1] Adjusted for differences in age, cigarette smoking, and hypertension.
[2] Opposite trend.
SOURCE: JAMA 252: 491-495, July 27, 1984. Used with permission of JAMA. Copyright 1984, American Medical Association.

data are not persuasive (*36*). In addition to endurance training, young adults should include as a part of their exercise regimen flexibility exercises and calisthenics or resistance exercises to maintain muscle tone and strength.

Adults (25 to 65 years). The possible health advantages for adults related to exercise include the prevention of coronary heart disease, maintenance of optimal body weight, improved psychological status, the decreased risk of type II diabetes due to enhanced insulin sensitivity, and increased bone density. In adults, we not only have data on changes in fitness measures as a result of physical activity or exercise, but also evidence that a greater number of active men and women incur fewer chronic degenerative diseases (*37–39*). The recent report by Paffenbarger and colleagues (*39*) suggests that physical activity benefits may not be limited to the primary prevention of coronary heart disease. It also shows that persons who exercise have a lower incidence of stroke, respiratory diseases, all cancers, and deaths from all causes than persons who do not exercise (table 2).

Consistent with these data on coronary heart disease are a number of previous reports that have observed lower rates in active people at similar or lower levels of energy expenditure than in nonactive people (table 3) (*40–46*). In most cases, the major differences in the incidence of coronary heart disease are between those people who do almost nothing and those who get some form of exercise (by moving their bodies around) on a regular basis.

Table 3. The amount of physical activity[1] associated with decreased coronary heart disease

Study	Rate per minute[2]	Total per day[3]	Type of activity
Job-related activity:			
North Dakota (US)(*40*)	5.0-8.0	300-600	Farming and laboring
Evans County (US)(*41*)	3.0-7.5	400-500	Farming and laboring
Railroad workers (US)(*42*)	5.0-8.0	350-600	Walking, climbing, hanging
HIP (NY)[4](*43*)	4.0-8.0	300-500	Walking, lifting, carrying
Longshoremen (SF)(*44*)	5.2-7.5	810	Cargo handling
Nonjob-related activity:			
Rose (UK)(*45*)	4.0-7.0	80-140	Walking 5 days per week
HIP (NY)(*43*)	4.0-12.0	250-500	Walking, recreation, home activity
College graduates (US)(*46*)	3.0-12.0	250	Walking, stair climbing, sports
Morris (UK)(*37*)	7.5	225	Recreation, home activity

[1] Measured in kilocalories expended.
[2] Estimated kcal per min expenditure for a 70-kg man.
[3] Estimated difference in total kcal per day expenditure between sedentary and active subjects.
[4] HIP = Health Insurance Plan of Greater New York.
SOURCE: Haskell, W.L.: Cardiovascular risks and benefits of exercise: the scientific evidence. *In* Sports medicine, edited by R. Strauss. pp 57-75. Used with permission of publisher W.B. Saunders Co., Philadelphia, PA, 1984.

This activity is quite diverse, with more "physical activity" than "exercise" reported.

A physical activity plan for adults should consist predominantly (more than 75 percent of time) of endurance activities performed frequently (three times per week or more) at a moderate intensity (50 percent to 75 percent of aerobic capacity). Ideally, activities should be selected that are convenient and enjoyable to perform. The goal of this activity plan should be to work up to expending 300 or more kilocalories per session. Either in conjunction with this activity or several other times during the week, some flexibility (especially for hamstrings, low back and shoulders) and strength development exercises should be performed. Many adults find that once they "get into shape" using a structured fitness program, they can comfortably perform various sports or recreational activities at an intensity that significantly contributes to their fitness improvement or maintenance.

Older adults (65 years and older). Many of the physical and mental manifestations that occur with getting older are inevitable. However, some of these debilitating effects are aggravated or accelerated by inactivity (*47*). The major goals for promoting activity for older adults include maintaining the ability to continue self-care and enjoy leisure-time pursuits; retention of musculoskeletal integrity (skeletal muscle strength and mass, bone mineral content, connective tissue strength, range of motion); the primary and secondary prevention of coronary heart disease and type II diabetes manifestations; and enhanced psychological status, including improved self-confidence and less depression and anxiety.

Studies evaluating the characteristics of activity that provide improvements in fitness in the older adult generally have demonstrated that much of the benefit is achievable by low- to moderate-intensity exercise (relative to the individual's capacity) (*48–50*). The prevention of prolonged bed rest or extensive periods of inactivity should be the initial goal of physical activity programs for all adults age 65 and over. The type of activity employed will depend upon the individual's specific goals; comprehensive programs include endurance, strength, and flexibility exercise. Simple activities that use familiar skills should be used, and any activity that requires sudden or powerful moves should not be considered. The use of prolonged static exercise should be avoided. However, short, intermittent static contractions may be useful for increasing muscle strength. All programs should include flexibility exercises for the back and shoulders.

Walking is the preferred aerobic activity for this age group with cycling, rowing, swimming, and other limited weight-bearing exercises being excellent alternatives. As demonstrated by Badenhop and coworkers (*50*), exercise that increases heart rate to 30 percent to 45 percent of heart rate reserve is as effective in increasing aerobic capacity in adults over the age of 60 as more intense exercise requiring 60 percent to 75 percent of heart rate reserve.

Physical Activity and Health Promotion

Some reasonably well-established facts regarding the characteristics of physical activity or exercise that contribute to an improvement in health-related physical fitness or clinical status include these:

1. Physically active people at all ages exhibit fewer health problems than the very sedentary. Some of this difference may be due to self-selection or associated health habits. Thus, the entire difference may not be caused by physical activity. Both observational and experimental data are available to support the causal role for exercise in both improved health–related fitness and decreased clinical manifestations of selected disorders.

2. Extreme inactivity has significant detrimental consequences on health status, but these effects are rapidly reversed by ambulation, the upright posture, and gravity. Thus, low–intensity activity has major health consequences for the very inactive.

3. The training principles of overload, specificity, and progression pertain to health-related fitness as well as enhanced physical working capacity.

4. The health benefits attributable to physical activity are relatively greater at the lower levels of activity. The improvement is greatest when the least-active individuals in the population are compared with the moderately active (expenditure of 200 to 300 kilocalories per day difference) with much less effect apparent between the moderately active and the very active.

5. Most benefits of exercise are produced by movement requiring the dynamic and rhythmic use of large muscles for an extended period of time. This exercise is most effective when it is performed frequently (daily to at least every third day) and at a moderate intensity relative to the individual's capacity. Additional benefits are provided by heavy resistive exercise that develops strength and exercises that increase flexibility.

6. Aerobic exercise performed at a moderate intensity (more than 50 percent of $\dot{V}O_2Max$ or heart rate reserve) for a duration that results in an energy

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expenditure of more than 4 kilocalories per kilogram of body weight per session at least every other day should be the minimum goal of adults who are otherwise sedentary.

Research Recommendations

1. Conduct studies to determine which health-related fitness measures should have the highest priority when assessing the effectiveness of health-oriented exercise training programs.
2. Scientifically determine the most effective and efficient methods of evaluating preselected health-related fitness measures in representative samples of the general population.
3. Define the dose-response relationship between exercise intensity, duration of the session (including multiple short sessions versus one larger session per day), and frequency, and the various health-related benefits as well as clinical manifestations of disease. Special emphasis should be placed on the issue of intensity because of its impact on public acceptance and its close association with medical risks. Since many people participate in activities on a seasonal basis, the effects of such participation on health-related measures also need to be understood.
4. Determine the most effective strategies for encouraging persons of all ages to engage in physical activity at the level necessary to achieve fitness.
5. Determine the relationship between the improvement in various psychological measures (for example, relief of anxiety and depression) and physical activity by examining the potential for environmental, social, mechanical, and biological factors to act as the required stimuli. What does it take to get people to feel better in general about themselves, be less anxious, or be less depressed? Is it just the activity or are major long-term psychological changes tied to acute or chronic biologic effects? Of special interest should be the role of exercise in relieving the psychological stress of patients with cancer or chronic obstructive pulmonary disease.
6. Evaluate the health-related benefits that are likely to occur for special populations, including those at high risk, such as people with genetically based lipid disorders, hypertensive patients, the psychologically depressed elderly, and pregnant women.
7. Determine what effect physical education in school has on the motivation to exercise later in life. How can children be motivated to develop life-long exercise habits? Will the development of clubs or community centers improve the transition from school sports to physical activity in later life?
8. Determine if there are people who need more exercise than others to maintain good health. If such people can be identified, will concentrating on those people be the most efficient way to plan exercise programs for optimal results?
9. Establish the influence, if any, of jogging or running on the development of arthritis or other degenerative musculoskeletal disorders. Is there a threshold beyond which the risk substantially increases? Is there a significant difference in any effect between weight-bearing and nonweight-bearing activities on the development of arthritis?
10. Determine the major reasons why people decrease their activity after age 25 and develop ways to eliminate this decline.

References

1. Siscovick, D. S., LaPorte, R. E., and Newman, J. M.: The disease-specific benefits and risks of physical activity and exercise. Public Health Rep 100: 180–188, March–April 1985.
2. Taylor, C. B., Sallis, J. F., and Needle, R.: The relationship between physical activity and exercise and mental health. Public Health Rep 100: 195–202, March–April 1985.
3. May, G. S., et al.: Secondary prevention after myocardial infarction: a review of long-term trials. Prog Cardiovasc Dis 24: 331–352 (1982).
4. Kemmer, F. W., and Berger, M.: Exercise and diabetes mellitus: physical activity as a part of daily life and its role in the treatment of diabetic patients. Int J Sports Med 4: 77–88 (1983).

5. Wilmore, J. H.: Training for sport and activity. ed. 2. Allyn and Bacon, Inc., Boston, MA, 1982.
6. Haskell, W. L.: Exercise induced changes in plasma lipids and lipoproteins. Prev Med 13: 23–36 (1984).
7. Bailey, D. A.: The growing child and the need for physical activity. *In* Child in sport and physical activity, edited by J. G. Albinson and P. R. Andrew. University Park Press, Baltimore, MD, 1976, pp. 81-96.
8. Smith, E. L., Reddan, W., and Smith, P. E.: Physical activity and calcium modalities for bone mineral increase in aged women. Med Sci Sports Exerc 13: 60–64 (1981).
9. Bahre, M. S., and Morgan, W. P.: Anxiety reduction following exercise and meditation. Cog Ther Res 2: 323–334 (1978).
10. Ransford, C. P.: A role for amines in the antidepressant effect of exercise: a review. Med Sci Sports Exerc 14: 1–10 (1982).
11. Cooper, K. H.: Aerobics. M. Evans and Co., Philadelphia, PA, 1968.
12. Saltin, B., et al.: Response to exercise after bed rest and after training. Circulation 38 (supp. 7): 1–78 (1968).
13. Deitrick, J. E., Whedon, G. D., and Shorr, E.: Effects of immobilization upon various metabolic and physiological functions in normal men. Am J Med 4: 3–36 (1948).
14. Rambaut, P. C., et al.: Comparative study of two direct methods of bone mineral measurement. Aerospace Med 43: 646–650 (1972).
15. Nikkila, E. A., Kuusi, T., and Myllynen, P.: High density lipoprotein and apolipoprotein A–I during physical inactivity. Atherosclerosis 37: 457–462 (1980).
16. Rodahl, K.: Physiological changes during prolonged bed rest. *In* Nutrition and physical activity, edited by Blix. Almquist and Wiksell, Stockholm, 1967, pp. 107–113.
17. DeBusk, R. F., Convertino, V. A., Hung, J., and Goldwater, D.: Exercise conditioning in middle–aged men after 10 days of bed rest. Circulation 68: 245–250 (1983).
18. LaPorte, R. E., et al.: The spectrum of physical activity, cardiovascular disease and health: an epidemiologic perspective. Am J Epidemiol 120: 507–517 (1984).
19. Percy, L. E., Dziuban, C. D., and Martin, J. B.: Analysis of effects of distance running on self concepts of elementary students. Percept Mot Skills 52: 181–187 (1981).
20. Dwyer, T., et al.: An investigation of the effects of daily physical activity on the health of primary school students in South Australia. Int J Epidemiol 12: 308–313 (1983).
21. Eriksson, B. O.: Physical training oxygen supply and muscle metabolism in 11–13 year old boys. Acta Physiol Scand (supp. 384) (1972).
22. Valimaki, I., Hursti, M. L., Pihlaskoski, L., and Viikari, J.: Exercise performance and serum lipids in relation to physical activity in school children. Int J Sports Med 1: 132–138 (1980).
23. Linder, C. W., and DuRant, R. H.: Exercise, serum lipids, and cardiovascular disease risk factors in children. Pediatr Clin North Am 29: 1341–1354 (1982).
24. Montoye, H. J.: Physical activity and health: an epidemiologic study of an entire community. Prentice–Hall, Inc., Englewood Cliffs, NJ, 1975, pp. 75–98.
25. Tucker, L. A.: Effect of a weight–training program on the self-concepts of college males. Percept Mot Skills 54: 1055–1061 (1982).
26. Karvonen, M. J., Kentala, K., and Mustala, O.: The effects of training on heart rate: a longitudinal study. Ann Med Exp Biol Penn 34: 307–310 (1957).
27. American College of Sports Medicine: Position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. Med Sci Sports Exerc 10: vii–x (1978).
28. Council on Scientific Affairs: Physician supervised exercise program in the rehabilitation of patients with coronary heart disease. JAMA 245: 116–121, Apr. 10, 1981.
29. Pollock, M. L.: How much exercise is enough. Physician Sports Med 6: 65–76 (1978).
30. Gaesser, G. A., and Rich, R. G.: Effects of high– and low–intensity exercise training on aerobic capacity and blood lipids. Med Sci Sports Exerc 16: 269–274 (1984).
31. Blair, S. N., et al.: Comparison of nutrient intake in middle–aged men and women runners and controls. Med Sci Sports Exerc 13: 310–315 (1981).
32. Allison, T. G., et al.: Failure of exercise to increase high density lipoprotein cholesterol. J Cardiac Rehabil 1: 257–265 (1981).
33. Leon, A., Conrad, J., Hunninghake, D., and Serfass, R.: Effects of a vigorous walking program on body composition, and carbohydrate and lipid metabolism of obese young men. Am J Clin Nutr 32: 1776–1787 (1979).
34. Sharkey, B. J.: Intensity and duration of training and the development of cardiorespiratory endurance. Med Sci Sports Exerc 2: 197–202 (1970).
35. Burke, E. J., and Franks, E. D.: Changes in $\dot{V}O_2$max resulting from bicycle training at different intensities holding total mechanical work constant. Res Q 46: 31–37 (1975).
36. Goldberg, L., Elliot, D. L., Schultz, R. W., and Kloster, F. E.: Changes in lipid and lipoprotein levels after weight training. JAMA 252: 504–506, July 27, 1984.
37. Morris, J. N., Pollard, R., Everitt, M. G., and Chave, S. P. W.: Vigorous exercise in leisure time: protection against coronary heart disease. Lancet 8206: 1207–1210 (1980).
38. Salonen, J. T., Puska, R., and Tuomilehto, J.: Physical activity and risk of myocardial infarction, cerebral stroke and death: a longitudinal study in Eastern Finland. Am J Epidemiol 115: 526–537 (1982).
39. Paffenbarger, R. S., Hyde, R. T., Wing, A. L., and Steinmetz, C. H.: A natural history of athleticism and cardiovascular health. JAMA 252: 491–495, July 27, 1984.
40. Zukel, W. J., et al.: A short-term community study of the epidemiology of coronary heart disease. Am J Public Health 49: 1630–1639 (1959).
41. Cassel, J., et al.: Occupation and physical activity and coronary heart disease. Arch Intern Med 128: 920–928 (1971).
42. Taylor, H. L., et al.: Death rates among physically active and sedentary employees of the railroad industry. Am J Public Health 52: 1697–1707 (1962).
43. Shapiro, S., Weinlatt, E., Frank, C., and Sager, R. V.: Incidence of coronary heart disease in a population insured for medical care (HIP). Am J Public Health 59: 1–101 (1969).
44. Paffenbarger, R. S., and Hale, W. E.: Work activity and coronary heart disease mortality. N Engl J Med 292: 545–550, Mar. 13, 1975.
45. Rose, G.: Physical activity and coronary heart disease. Proceedings of the Royal Society of Medicine, 62: 1183–1186, London 1969.
46. Paffenbarger, R. S., Wing, A. L., and Hyde, R. T.: Physical activity as an index of heart attack in college alumni. Am J Epidemiol 108: 161–175 (1978).

47. Bortz, W. M.: Effect of exercise on aging: effect of aging on exercise. J Am Geriatr Soc 28: 48-51 (1980).
48. DeVries, H. A.: Exercise intensity threshold for improvement of cardiovascular-respiratory function in older men. Geriatrics 26: 94-101 (1971).
49. Emes, C. G.: The effects of a regular program of light exercise on seniors. J Sports Med Physical Fitness 19: 185-189 (1979).
50. Badenhop, D. T., et al.: Physiologic adjustments to higher- or lower-intensity exercise in elders. Med Sci Sports Exerc 15: 496-502 (1983).

The Promotion of Physical Activity in the United States Population: The Status of Programs in Medical, Worksite, Community, and School Settings

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Synopsis ....

While the medical care encounter is considered an ideal situation in which patients are encouraged to increase their physical activity levels, very little research has been conducted in this setting. In fact, with the exception of the physical activity components of cardiac rehabilitation programs, few formal physical activity programs are available in medical care settings.

Although the workplace is currently the focus of the greatest interest by those persons who implement physical activity programs, there is little precision in defining what constitutes a worksite physical activity program. A number of researchers and authors, using program experience rather than empirical findings, have described what they believe to be the important components of successful worksites health promotion and physical education programs.

The greatest variety of physical activity programs are found in community settings. They are offered by a number of nonprofit private organizations, nonprofit public agencies, and for-profit organizations. While relatively little research has been done concerning changes in the community environment, it is clear that such changes can effect community participation. Community campaigns to increase physical activity have been studied, and it appears that they clearly affect residents' interest and awareness in physical activity, but they do not have a major effect on behavioral changes in the short term.

It appears that a major opportunity to influence favorable physical activity in the United States is being missed in schools. A large majority of students are enrolled in physical education classes, but the classes appear to have little effect on the current physical fitness levels of children and, furthermore, have little impact on developing life-long physical activity skills.

WHAT IS KNOWN about physical activity participation during leisure time in both Canada and the United States has been described by Stephens and co-workers (*1*).

In addition, Dishman and co-workers have pointed out that we really know very little about when, why, or how people change their health behaviors, but we do know that most persons who make health behavior changes do so on their own, seemingly with little or no outside assistance (*2,3*).

This may also apply when people change their exercise behavior. If persons who are physically active exercise on their own or in groups without attending a formal physical activity program (aerobic dance class) or a restricted fitness facility (exercise room for employees of company x), then