Exercise is Medicine™

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PEARCE, P.Z. Exercise is medicine™. *Curr. Sports Med. Rep.*, Vol. 7, No. 3, pp. 171–175, 2008. *The medical benefits of regular physical activity, including weight loss and reduction in the risk of heart disease and certain cancers, are well known. Physicians are still reluctant, however, to prescribe exercise for their patients. Although many cite lack of time or poor reimbursement for counseling services, I believe the majority of primary care physicians are simply unsure of how to effectively begin discussing exercise with their patients. This article will review the medical benefits of exercise, basic principles of physiology, and then the components of an exercise prescription. With 250,000 deaths each year attributed to a sedentary lifestyle, it is incumbent upon physicians to include a discussion of regular physical activity with their patients, at every visit.*

INTRODUCTION

Cardiovascular disease (CVD) has been the single leading cause of death among Americans since 1900, according to data compiled by the U.S. Public Health Service, and the U.S. National Center for Health Statistics (1,2). The major risk factors for CVD obviously include hypertension, hyperlipidemia, cigarette smoking, and diabetes, but epidemiologists in the 1950s and 1960s began to investigate the contribution of a sedentary lifestyle (3). Physical activity became a major focus of the landmark Harvard Alumni Study (4), and in 1990, an independent meta-analysis of many trials concluded that lack of exercise carries the same relative risk of heart disease as cigarette smoking. This was quite significant, since at that time only one fourth of the population smoked, but 70%–80% were considered sedentary (5). The Surgeon General's report of 1996 brought this to the attention of the general population and stressed the contribution that leisure-time activity made in promoting general health and well-being (6) (Table).

Exercise likely achieves its cardioprotective effect, by mitigating the two major risk factors: hyperlipidemia (7) and hypertension (8). The latter is likely mediated by an increase in endothelial nitric oxide production, which results in vasodilation (9). In addition, regular physical activity has an impact on all-cause mortality, through its effects upon other disease states. Exercise and a proper diet promote weight loss, thereby decreasing the risk of type II diabetes and subsequent heart disease. The incidence of several cancers, including breast (10), colon (11), and endometrium, also is reduced in those who regularly exercise (12). In addition to improving overall well being, it is one of the best stress relievers (13) and greatly reduces a patient's reliance on antidepressant medication (14). Exercise is associated with improved bone health, and in the elderly decreases the risk of falls, thereby promoting independence (15). Finally, regular physical activity is a mainstay in the management of fibromyalgia (16).

Unfortunately, the past 16 years have seen a dramatic increase in the incidence of obesity, implying a decline in the number of Americans who exercise. Data from the U.S. Centers for Disease Control and Prevention indicate that the incidence of obesity (BMI > 30) for U.S. adults aged 20–74 increased from 15% in the 1976–80 National Health and Nutrition Examination Survey (NHANES) to 32.9% in 2003–2004. Obesity is an independent risk factor for CVD, and the direct result of inactivity (17). There are several reasons physicians offer in explaining why medications are more commonly prescribed than exercise, including lack of time with patients, poor reimbursement for counseling services, and inadequate training in exercise physiology (18). The American Association of Family Physicians and American Board of Family Practice are being proactive, by introducing Sports Medicine rotations into the curriculum of Family Practice Residencies. Recently, Robert E. Sallis, M.D., FACSM, president of American College of Sports Medicine, along with Ronald M. Davis, M.D. president of the American Medical Association, launched the Exercise is Medicine™ program, with an informative Web site for those of us "baby boomers" who have long since completed

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training (19). It provides valuable information for physicians and links to other sites that help demystify exercise prescription for your patients. This article will conclude with a concise summary of basic exercise physiology and the practical aspects of developing an exercise program.

BASIC PHYSIOLOGY

I often hear patients say that they would like to be healthier but "can't run a marathon" to do it. While it is true that intensity of physical activity is inversely and linearly associated with mortality, it has been shown that all of the medical benefits of exercise can be achieved from the lowest levels of energy expenditure. In other words, there exists an inverse gradient of health risks across self-reported physical activity groups (20). The work of Dr. Ralph Paffenbarger demonstrates fitness benefits in those who expended a minimum of 2000 kcal (8400 kJ) per week, but more recent studies have shown a reduction in all-cause mortality of 20%–30% in those who expend only 1000 kcal (4200 kJ) per week (21). As little as 500 kcal (2100 kJ) per week may provide a fitness benefit to the frail and elderly, extending the benefits of exercise to other populations (22). Sedentary patients might be more likely to begin an exercise program if they know that they can receive a fitness benefit for their effort. Blair and colleagues have similarly argued that it is preferable to encourage people to become more physically active as opposed to physically fit, since sedentary people are more likely to expend at least the minimum amount of energy (23).

From the above discussion, it is obvious that a more detailed understanding of exercise physiology is not necessary to develop an exercise program. However, some patients will pursue physical fitness more aggressively, so a brief introduction to exercise physiology is warranted. Muscular work requires energy derived from the metabolism of adenosine triphosphate (ATP) to adenosine diphosphate (ADP). It is an inefficient conversion, as 70% of this reaction is released in the form of heat. To replenish the stores of ATP, muscle cells can utilize either of two metabolic systems, depending upon the intensity of effort. The most efficient means of converting fuel to ATP is to oxidize it inside of the mitochondrial matrix, through a series of enzyme-catalyzed steps known as the citric acid, or tricarboxylic acid (TCA), or simply "Krebs" cycle. It is highly efficient, and when combined with oxidative phosphoryllation through the electron transport chain, produces a maximum of 38 ATP for every molecule of glucose consumed. This "aerobic" metabolism can utilize carbohydrate, protein, fat, and even lactic acid as an energy source, and is the favored method of energy production at low levels of effort. It follows that oxygen-uptake is the rate-limiting step in energy production, and is therefore linearly proportional to work intensity. Fortunately, heart rate parallels oxygen consumption, providing us with a simple and effective means of monitoring exercise intensity. As workload increases, however, there is a point at which blood rich with oxygen and fuel can no longer supply the working muscles. To continue exercising, cells must forego the mitochondria and ferment fuel to ATP in the cytoplasm. This is termed "anaerobic" metabolism and is not nearly as efficient, yielding only two net ATP per glucose molecule. When muscle cells ferment glucose, they produce lactic acid as a byproduct, which slows activity if allowed to accumulate. Also, glucose is the only fuel that can be fermented, so weight loss in the form of fat metabolism does not occur. The critical determinant of which system a cell uses is intensity of effort. The level of effort at which muscle cells switch from mostly aerobic to mostly anaerobic metabolism is termed the anaerobic threshold (A/T), lactate threshold, or the onset of blood lactate accumulation (OBLA). One of the most important performance variables athletes train to improve is raising the heart rate at which A/T or lactate threshold occurs. This allows them to remain aerobic, and therefore more efficient, at higher levels of intensity (24).

What exactly is "cardiovascular fitness?" Several physiological adaptations occur with regular exercise, and from the above discussion it would seem logical that the cardiovascular, pulmonary, and musculoskeletal systems would be responsible. Cardiovascular changes in response to exercise include increased left ventricular wall thickness (athlete's heart), increased left ventricular end-diastolic volume, and decreased end-systolic volume (resulting in increased ejection fraction), with maintenance of cardiac output at rest or submaximal workloads. Individuals who train regularly retain extra plasma volume, expand red cell mass, and have decreased viscosity of their blood (25). Pulmonary adaptations include increased total lung volume and tidal volume, with decreased residual volume. There is decreased respiratory rate at rest and any submaximal work load, but increased respiratory rate, pulmonary ventilation, and pulmonary diffusion at maximal exertion (26). Probably the most notable cardiovascular adaptation to exercise is decreased heart rate at rest and any submaximal work load, known as the training effect (27). This is actually not a cardiovascular or pulmonary phenomenon, but the result of improved muscular efficiency. Muscle cells adapt to exercise by hypertrophy, increased capillary blood flow, greater glycogen storage, and increased numbers of mitochondria. This latter effect is somewhat irreversible, and athlete muscle biopsies after years of inactivity still demonstrate 75% of the mitochondria they had when training regularly (28). The end result is that muscles can extract more oxygen and fuel from the blood with reduced effort, therefore decreasing the respiratory and pulse rate at rest, and any submaximal level of exertion.

EXERCISE PRESCRIPTION

Obviously the first step in writing an exercise prescription is to determine whether increased physical activity is safe for your patient. Begin with a complete history and physical, blood chemistry screen, EKG, and treadmill if the patient is over 45 yr of age or has more than two American Heart Association risk factors (29). A submaximal treadmill has the added advantage of providing a fitness assessment, and important information concerning heart rate training zones. In the absence of a formal exercise tolerance test (ETT), there is a very simple way to obtain this information. The

Rockport Institute has developed a 1-mile walking fitness assessment that is available online (30). Patients walk 1 mile briskly, then record their total elapsed time and finishing heart rate. Nomograms are available to estimate $\dot{V}O_{2max}$ and training heart-rate zones, based on their current level of fitness. Also included are fitness walking programs, which will be discussed later.

With that background, we now have enough information to design a program for our patients. Exercise is like medication and can be prescribed with an intensity, duration, and frequency. First of all, exercise should be aerobic, which implies large muscle groups in continuous motion at a moderate intensity. But exercise also should be fun; otherwise, patients are not likely to continue the program, especially during the difficult early phase of developing a fitness base. Intensity and duration are inversely related to each other, so patients can either select short duration efforts of higher intensity, or less demanding activities for a longer period of time (Table). Once again, for a fitness benefit, leisure activity should be performed on most days of the week. The following paragraphs outline one approach to developing an exercise program for sedentary patients.

Motivation

Lao Tzu, father of Taoism and contemporary of Confucius, once said, "A journey of a thousand miles begins with a single step." How simple it should be, but motivation remains to this day the greatest stumbling block in developing an exercise program for your patients. While many believe more lasting results will occur when the desire comes from within (31), it is still incumbent upon us as physicians to offer exercise to our patients (32). Once the decision has been made to pursue a more active lifestyle, there are many "tricks" that will make exercise a part of their daily routine and help to maintain the program. As clinicians, we should encourage exercise at every visit and discuss the benefits (above), so our patients are informed. Start with a realistic goal; for example, a reduction in body weight of 5%–15% is associated with fitness benefits (33). Have them keep a journal or log, brag to friends about their progress, and reward themselves for small accomplishments. Once they achieve that goal, have them set a new one and refocus. Choosing an exercise that they want to do or have done in the past is helpful. It is important to set time aside each day, because if left to chance, there is the opportunity to put it off. In that respect, one of the greatest tricks is to begin exercising with a friend, because they are likely to be motivated on days your patient would rather skip a workout, and other times the friend can return the favor.

TABLE. Common activities that burn 150 kcal (minutes).

Activity	Pace	Minutes
Washing and waxing a car		45–60
Washing windows or floors		45–60
Playing volleyball		45
Playing touch football		30–45
Gardening		30–45
Wheeling self in wheelchair		30–40
Walking 1.75 miles	20-min mile	35
Basketball (shooting baskets)		30
Bicycling	10 mph	30
Dancing fast (social)		30
Pushing a stroller	1.5 miles	30
Raking leaves		30
Walking 2 miles	15-min mile	30
Water aerobics		30
Swimming laps		20
Wheelchair basketball		20
Basketball (playing a game)		15–20
Bicycling	16 mph	15
Jumping rope		15
Running 1.5 miles	10-min mile	15
Shoveling snow		15
Stairwalking		15

Flexibility

Most of what we know about stretching comes from the field of sports and injury prevention; however, lack of flexibility also is one of the most detrimental effects of aging. In the elderly, it is associated with poor balance, further limiting activity, and ultimately resulting in loss of independence. Most people are sedentary, and sedentary people are generally inflexible, thereby contributing to their overall symptom complex. When starting an exercise program, begin with a few weeks of flexibility stretches. This is a non-threatening introduction to exercise, and in addition to preparing them for exercise, is somewhat therapeutic itself. While a detailed stretching program is beyond the scope of this article, a great resource is the book *Stretching*, by Bob Anderson (34). Stretching should almost be a meditative experience, long and slow, concentrating on the muscle to be relaxed. Stretch in the morning to prepare for the day, and again just before bed. It is more effective then, because patients remain horizontal, and are not weight-bearing. Stretching of the calf muscles also helps prevent nocturnal leg cramps, so they sleep better. Two weeks of flexibility work is a painless introduction to exercise and will prepare them for the next phase of training, muscular strength.

Strength

Strength is obviously necessary to perform the work required of aerobic exercise, but increased muscle mass also contributes to weight loss. As opposed to fat, muscle is metabolic tissue, requiring energy even in the resting state. One of the reasons skinny people stay thin is that individuals with greater lean-body mass burn more calories, even at rest. It is known that twice as many calories are burned after an exercise session as during exercise, while your body replenishes glycogen stores and prepares for another exercise session. The metabolic rate remains elevated and returns to baseline 60 min after a 30-min exercise session at 70% $\dot{V}O_{2max}$ (35). Fat is the primary source of energy at rest, supplying 70% of needed calories. Therefore, if you want to lose body fat, build more muscle and exercise aerobically.

There are two major divisions of the muscular system that must be considered when planning a strength program: the trunk (core) and extremities. Most people and many athletes have unbalanced core strength, which predisposes to injury. It is quite common to bend at the waist and lift improperly, so we tend to over-develop the back extensors. Usually the trunk flexors (abdominals) and rotators are the weakest, so sit-ups and leg lifts should be incorporated into a core training program (36). After a few weeks of working on flexibility, start with a week of core exercises, then expand training to include the extremities. This has the advantage of slowly introducing your patient to physical exercise and preparing them for the demands of aerobic endurance activity. A detailed discussion of weight training is beyond the scope of this article, so those readers who desire further information are directed to one of the many excellent references available (37).

Endurance

The centerpiece of any exercise program is aerobic endurance training. It is the activity your patients will pursue in their goals to fitness, so they should spend some time in choosing something enjoyable. Explore their exercise history, and help them select something that is appropriate for any pre-existing medical conditions or physical limitations. Remember that a fitness benefit results when expending as little as 150 kcal per day, 6 d of the week. The Table contains a list of leisure-time activities meeting that requirement. For those who need direction, recommend walking. It is cheap, effective, and the duration can be increased as fitness improves. The Rockport Institute has a fitness walking program outlined on its Web site. The 1-mile walk test defines a patient's level of fitness, then outlines a 20-wk walking program, based on age and sex. After the initial 20 wk, they should demonstrate a training effect, or decreased heart-rate for any submaximal level of exertion. Completing another 1-mile walk test should then take less time, or result in a lower heart rate at the end, defining a different fitness level and 20-wk program. For those with arthritis, who cannot tolerate weight-bearing activity, encourage cycling. It can be done indoors in the winter, and like walking, the pace and duration can be varied as fitness improves. Swimming, on the other hand is too technique-intensive and predisposes to injury, unless the patient has a background in that sport (38).

CONCLUSION

Exercise is a safe, inexpensive, and effective alternative to prescription medication and is appropriate for most patients. Expending as little as 150 kcal per day, on most days of the week, will enhance a patient's fitness level. That amount of activity does not require any special equipment or visits to a health facility and can be met by leisure-time activities, such as gardening, dancing, or raking leaves. In addition to improving overall well-being, benefits include weight loss and reduction in the risk of death from all causes, likely because of an impact upon the incidence of cardiovascular disease and certain cancers. I join the American College of Sports Medicine in urging practitioners to adopt the philosophy that *Exercise is Medicine™*. Discuss physical activity at every visit, and encourage your patients to become more active. The Nike Corporation was prophetic with its old marketing campaign that simply stated, "Just Do It."

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