Exercise Prescription

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Background

Exercise prescription commonly refers to the specific plan of fitness-related activities that are designed for a specified purpose, which is often developed by a fitness or rehabilitation specialist for the client or patient. Due to the specific and unique needs and interests of the client/patient, the goal of exercise prescription should be successful integration of exercise principles and behavioral techniques that motivates the participant to be compliant, thus achieving their goals.[1,2,3,4,5,6,7]

Components of exercise prescription

An exercise prescription generally includes the following specific recommendations:

- Type of exercise or activity (eg, walking, swimming, cycling)
- Specific workloads (eg, watts, walking speed)
- Duration and frequency of the activity or exercise session
- Intensity guidelines – Target heart rate (THR) range and estimated rate of perceived exertion (RPE)
- Precautions regarding certain orthopedic (or other) concerns or related comments

For an explanation of terms, see Glossary of Terms.

Introduction

Substantial data are available regarding the benefits of physical activity.[1,2,3,4,5,6,7] For primary preventative benefits, physical activity patterns should begin in the early school years and continue throughout an individual's life. Schools must specifically designate physical education programs with aerobic activities for children at early ages. Programs should include recreational sports (eg, running, dancing, swimming). Support at home for an active lifestyle for children helps to promote healthy physical activity patterns.

In the clinical setting, discuss physical activity and provide exercise prescriptions for patients and their families. In some instances, suggestions could be made about implementing physical activity recommendations at the work site.

Consider intensity, duration, frequency, mode, and progression in all types of physical activity programs. As children and adolescents become adults and discontinue the athletic endeavors of school and college, primary prevention must include a plan for a lifetime of appropriate physical activity. Ideally, this activity should be performed for at least 30-60 minutes, 4-6 times weekly or 30 minutes on most days of the week. The frequency, duration, and intensity of activity should be individualized (exercise prescription) to personal satisfaction, mode, and progression.

Subjects may use individual end points of exercise, such as breathlessness and/or a fatigue level ranging from somewhat hard to hard on the Borg perceived exertion scale (see Glossary of Terms, Borg rating of perceived exertion [RPE]). Standardized charts that designate heart rates may help by providing heart rate end points that can be measured immediately after exercise, but these are not necessary. Exercise should include aerobic activities, such as bicycling (stationary or

routine), walk-jog protocols, swimming, and other active recreational or leisure sports. Shoes and clothing should be appropriate for extremes of heat, cold, and humidity.

Resistive exercises using free weights or standard equipment should be performed 2-3 times per week. These exercises should include 8-10 exercise sets that consist of 10-15 repetitions per set (including arms, shoulders, chest, trunk, back, hips, and legs) and are performed at a moderate intensity. If free weights are used, 15-30 lb is generally adequate or resistance that requires a perceived effort that is relatively hard (ie, an RPE 15-16). Resistive exercises tend to complement aerobic exercise in that some training effect is realized.[8] However, as adults age, development of muscle tone and strengthening of body musculature is more important.

The long-term effect of any physical activity program is affected by compliance. In today's mobile society, an exercise plan must include activities for business trips and vacations. Exercise facilities may not be convenient in such settings, which may mean improvising. For example, a walk-jogger should bring walking or running shoes and find a safe place to walk or run at a pace that approximates the usual activity level. Many hotels or motels have exercise facilities with a track or treadmill, exercise cycle, and weights, enabling travelers or others away from their usual routine to maintain an exercise program.

Physical activity measured in total time or kilocalories (kcal) or kilojoules (kJ) per week is appropriate and may be achieved with various combinations of scheduling, such as 10-15 minutes in the morning, at noon, and/or an afternoon/evening session. Many persons may schedule longer, less frequent periods of exercise. As intensity decreases, frequency and duration should increase and vice versa. The dosage or total energy (calorie) expenditure per week must be individualized (exercise prescription).

Persons with influenza syndromes or respiratory illnesses should decrease or stop exercise until they have recovered. If the recovery time is greater than 2-3 weeks, activity should be resumed at a lower level to compensate for the slight loss in training level. Maintenance of the cardiovascular training effects of exercise has been shown to be more related to the exercise intensity than to exercise frequency or duration. In other words, if the intensity is maintained, even though the exercise sessions are less frequent or shorter in duration, transient reductions in conditioning from the decreased exercise appears to be minimized.

Various exercise testing measures of functional capacity should be used in special populations but are not necessary for primary prevention. Traditionally, many athletically inclined persons like to have periodic oxygen-uptake (VO_2) measurements to assess their level of training. However, recent technologic advances have not only made cardiopulmonary (CPX) or metabolic (CMET) testing more commonplace among medical practices, but they have also become increasingly popular as a part of a routine physical and stress test evaluation, especially for individuals who are considered at high risk for cardiovascular disease (eg, those with hypertension, shortness of breath, chest discomfort, or abnormal blood lipid levels).

A lifestyle of physical activity from childhood throughout the adult years fosters health and longevity. Even brisk walking as a physical activity/exercise habit promotes health benefits. This is the simplest program for most individuals and has clear benefits. This improved state of health is enhanced by weight control, restricted intake of saturated fat and cholesterol, abstinence from cigarette smoking, and control of high blood pressure and glucose intolerance.

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Benefits of Exercise

Routine exercise improves tissue VO_2 affects the following:

- Improves insulin sensitivity
- Improves glycemic control in persons with type 2 diabetes (and, hence, decreases overall mortality)[9]
- Decreases blood pressure
- Decreases low-density lipoprotein and triglyceride levels
- Increases high-density lipoprotein levels

Considerable data also support evidence that exercise may decrease the prevalence of colon cancer and endometrial cancer. Exercise also helps with osteoarthritis and obesity, as well as reportedly benefits persons with migraine headaches and fibromyalgia.

Middle-aged men and women who work in physically demanding jobs or perform moderate to strenuous recreational activities have fewer manifestations of coronary artery disease than their less active peers. Meta-analysis studies of clinical trials reveal that medically prescribed and supervised exercise can reduce mortality rates for persons with coronary artery disease.[1,7,10,11,12,13,14]

In a meta-analysis of 33 studies that included almost 200,000 participants and cases, Kodama et al quantified the relationship between better cardiorespiratory fitness and lower rates of coronary heart disease (CHD) and cardiovascular disease (CVD) events, as well as deaths from all causes.[15] When cardiorespiratory fitness was estimated as maximal aerobic capacity (MAC) expressed in metabolic equivalent (MET) units, a MAC of ≥7.9 METs was associated with substantially lower rates of CHD/CVD events and all-cause mortality.[15]

Furthermore, categorization of cardiorespiratory fitness as low (<7.9 METs), intermediate (7.9-10.8 METs), or high (≥10.9 METs) yielded risk ratios (RRs) for CHD/CVD in low-fitness participants of 1.47 compared with intermediate-fitness participants and 1.56 compared with high-fitness participants. The corresponding RRs for all-cause mortality in low-fitness versus intermediate-fitness participants was1.40 and that of low-fitness versus high-fitness participants was 1.70 (P <0.001).[15]

Several studies suggest that relatively small amounts of physical activity show considerable reductions in mortality and improved health outcomes among participants when compared with sedentary control subjects. These findings imply that a minimal activity (ie, exercising once per week) may have positive health benefits even though fitness may not be measurably improved. Some authors have suggested that a threshold of physical activity may be necessary for maintaining optimal health and that future investigations should involve control subjects who participate in at least minimal activity levels rather than comparing exercise treatment groups to control subjects who are completely sedentary.

In addition to the physical benefits of exercise, both short- and long-term aerobic exercise training is associated with improvements in various indexes of psychologic functioning. Cross-sectional studies reveal that compared with sedentary individuals, active persons are more likely to be better adjusted, to perform better on tests of cognitive functioning, to exhibit reduced cardiovascular responses to stress, and to report fewer symptoms of anxiety and depression.

In one report, persons who increased their activity levels from 1965-1974 were at no greater risk for depression than those individuals who were active all along; however, persons who were active and became inactive were 1.5 times as likely to become depressed by 1983 compared with those who maintained an active lifestyle. Longitudinal studies have also documented significant improvement in

psychologic functioning. Exercise training reduces depression in healthy older men and in persons with cardiac disease or major depression.

Exercise also improves self-confidence and self-esteem, attenuates cardiovascular and neurohumoral responses to mental stress, and reduces some type A behaviors. Although exercise training generally has not been found to improve cognitive performance, short bouts of exercise may have short-term facilitative effects.

Despite the positive physical and mental health benefits of exercise, long-term adherence to exercise programs remains problematic. Overall physical activity levels decrease with aging, in minority populations, in females, in disabled persons, and in those with chronic disease. Only an estimated 50% of all persons who initiate an exercise program continue the habit for more than 6 months. The issue of nonadherence is particularly important because exercise is only beneficial if it is maintained for extended periods. Thus, developing strategies to improve exercise initiation and adherence, especially for persons who are among the least active (eg, 75% of black women; less educated, obese, elderly persons), is important.[16,17,18,19,20,21]

Different Types of Exercise

Exercise has been defined as an activity for the express purpose of improving fitness or health. Physical activity includes all forms of activity (eg, occupational, recreational, sports-related) that are performed without the specific purpose of fitness or health. Different types of exercise are as follows:

- Aerobic (eg, walking, swimming)
- Anaerobic (eg, sprinting)
- Isotonic (eg, lifting weights)
- Resistance training: This involves providing some form of resistance to the contracting muscles to stimulate the body to increase strength. Multiple types of equipment are used for resistance training, including hand weights; cam machines; pulleys; and hydraulic, elastic, rubber, fiberglass, and magnetic equipment.
    - Strength or resistance training is very important to improve functionality and reduce the risk of injury. As people age, the lean tissue (ie, muscle) declines more from lack of use than from aging itself. Regularly performing some type of resistance training is imperative.
    - Because the demand on the heart is generally less during strength training than while walking at a moderate pace, resistance training is regarded as safe for patients with many heart conditions. Patients should never strain or hold their breath while attempting to lift something; straining can adversely affect blood flow to the heart.

General Guidelines

Resistance and repetitions

- Resistance: The appropriate resistance may be provided by hand weights, elastic resistance, calisthenics, or machines and should be no more than what one can lift for approximately 15-20 repetitions. Perceived effort should only be moderate or somewhat hard.
- Repetition: A set is a group of repetitions, such as 2 or 3 sets of 15 repetitions. The number of sets depends on several factors, including time constraints, motivation, and personal goals. One to 3 sets are adequate for strength development. Add 1 set per week, increasing up to 3 sets.

- Progress: Progression can be made as one finds that the weight being used can be lifted more than 20-25 times. One should then increase the resistance slightly (eg, add 1-5 lb) and resume the training. As one reaches muscle fatigue, more stimulation of the muscle tissue results in protein being added to the muscle groups. Significant strength changes generally occur within 6 weeks.
- Other: Stretching should also be part of the exercise plan.

Type of exercise (mode)

- Intensity: This should range from low to moderate for healthy individuals.
- Duration: Continuous aerobic activity for 20-60 minutes is recommended.
- Frequency
    - Individuals with a less than a 3-MET capacity should engage in multiple short sessions each day.
    - Individuals with a 3- to 5-MET capacity should engage in 1-2 sessions per day.
    - Individuals with a greater than 5-MET capacity should engage in 3-5 sessions per week.

Energy (caloric) expenditure

- Per-minute calculation: To calculate kilocalories per minute (kcal/min), multiply the METs times 3.5 times body weight in kilograms (kg) and divide by 200 (ie, kcal/min = [METs × 3.5 × kg body weight]/200). For example, the energy (caloric) expenditure of a 70-kg individual at a prescribed 6-MET capacity with a weekly goal of 1000 per week is calculated as (6 × 3.5 × 70 kg)/200, which equals 7.35 kcal/min (30.87 kJ/min). To convert kilocalories to kilojoules, note that 1 kcal = 4.2 kJ.
- Per-week calculation: This determines the exercise duration per week. Using the numbers from the example above, divide 1000 kcal (4200 kJ) by 7.35 kcal/min (30.87 kJ/min), which equals 136 min/wk or approximately 20-30 minutes, 6 d/wk.

Lifetime activities

- Vary the type of activity. Pick an activity that is enjoyable. The activity can be any type that uses most muscles, elevates the heart rate, and may be sustained for 20 minutes or longer. For example, one may find stationary cycling boring but enjoy playing tennis or racquetball.
- Vary the duration and intensity within the guidelines. Some days, decrease the intensity of the activity but increase the duration. On other days, warm up and then increase the intensity to the upper range of the guidelines but decrease the duration.
- Contract with a friend (buddy system) or participate in group classes.
- Use music for rhythm. If an activity is boring, either change it or find another one that is enjoyable. For example, if one is stationary cycling, videos that show outdoor scenery are available. Also, new saddles are available that make cycling much more comfortable.
- Make exercising enjoyable by selecting at least 2 activities that are enjoyable.
- Conditioning may be realized from many activities if applied correctly.
- Walk daily, whether one has a dog or not.

Selecting the right physical activities

- Select physical activities that are enjoyable, use most of the muscles, are rhythmic, and may be sustained for several minutes to an hour.
- Plan to exercise every other day until more adequately adapted to the activity.

- Think of the frequency, intensity, time, and type (ie, FITT) plan.
    - Frequency: This is how often per week one will perform the exercise. Plan on most days of the week.
    - Intensity: This is how hard one exercises. Moderate effort is appropriate.
    - Time: This is the duration of each session. Start off with as little as needed (10 min if necessary).
    - Type: This is the choice of physical activity, which can include recreational activities and domestic or occupational activities. A short list of each follows:
        - Recreational activities
            - Participating in aerobic activity classes; performing calisthenics, gymnastics, low-impact aerobics, martial arts
            - Backpacking, climbing hills, stair climbing, walking, hiking, orienteering, running
            - Playing badminton, baseball, basketball, catch (eg, flying discs), cricket, handball, racquetball, lacrosse, rugby, shuffleboard, table tennis, tennis, volleyball, water polo
            - Body building, bowling, boxing, cycling, dancing, fencing, gardening, golfing, horseback riding, hunting, in-line skating, skating, rope skipping, skiing, snow shoeing, weight lifting, windsurfing
            - Canoeing, sailing, scuba diving, swimming, fishing, participating in water activities
        - Domestic or occupational activities – Cleaning windows, doing housework, mowing, packing and unpacking, plowing, sanding, sawing, sweeping, stocking shelves, pushing a wheelbarrow, performing yard work, etc
- Set goals, which may include those regarding health, improving physical capacity or performance.
- Motivation may be helpful for compliance. See the following tips:
    - Join a class or facility, or contract with a friend (buddy system).
    - Listen to one's body (eg, slowing down or skipping if tired or ill). Start at the present level to prevent soreness.
    - Exercise at the same time each day.
    - Make sure to have good-quality nutrition.
    - Make exercising a priority; scheduling a time benefits the individual.
    - Get advice if help is needed.

Exercise Prescription for Special Populations

Advanced age

- Maximum ventilatory perfusion (VQ) drops 5-15% per decade in individuals aged 20-80 years. A lifetime of dynamic exercise maintains the individual's VQ at a level higher than that expected for any given age. The rate of decline in VQ is directly related to maintenance of the physical activity level, which emphasizes the importance of physical activity.
- Developing and maintaining aerobic endurance, joint flexibility, and muscle strength is important in a comprehensive exercise program, especially as people age. Elderly women and men show comparable improvement in exercise training, and adherence to training in elderly individuals is high.
- Resistance training exercise alone has only a modest effect on risk factors compared with aerobic endurance training, but resistance training does aid carbohydrate metabolism through the development or maintenance of muscle mass and effects on basal metabolism.

Furthermore, resistance training is recommended by most health promotion organizations for its effects on maintenance of strength, muscle mass, bone mineral density, functional capacity, and prevention and/or rehabilitation of musculoskeletal problems (eg, low back pain).

- In elderly individuals, resistance training is both safe and beneficial in improving flexibility and quality of life. Persons with cardiovascular disease are usually asked to refrain from heavy lifting and forceful isometric exercises, but moderate-intensity dynamic strength training is safe and beneficial in persons at low risk.

Pulmonary disease

- Individuals with pulmonary disease should engage in low workloads of short duration.
- Patients should exercise in frequent intervals rather than a longer duration and fewer intervals.
- Supplemental oxygen is needed.

Diabetes

- Exercise should be of short duration with a gradual progression to longer durations, as tolerated.
- Exercises include aquatic aerobics, swimming, walking, jogging, or bicycling, among others.
- Monitor blood sugar because hypoglycemia or hyperglycemia can occur in diabetic persons during exercise.
    - Before exercise: Consume a meal 1-3 hours before exercising, administer insulin at least 1 hour before exercise, and, if the blood glucose level is greater than 250 mg/dL, check urine for ketones.
    - During exercise: Supplement energy (caloric) intake every 30 minutes and maintain adequate fluid replacement.
    - After exercise: Monitor the glucose level, increase energy (caloric) intake for 12-24 hours following activity, and expect postexercise hypoglycemia; thus, appropriately adjust insulin dosing.

Obesity

- Individuals who are morbidly obese should be cautious of orthopedic stresses.
- They may start with non–weight-bearing exercises (eg, swimming, water aerobics, floor exercises).
- These individuals should avoid high-impact aerobic activities.
- Emphasize duration as tolerated and exercise frequency (sessions per week).
- Emphasize premeal exercise, especially exercise in the morning before eating breakfast to mobilize fats (lipolysis).

Maternity

- Research on exercise during pregnancy continues to demonstrate marked benefits for the mother and fetus.[22,23,24,25,26] The type, intensity, frequency, and duration of the exercise seem to be important determinants of its beneficial effects.
- Maternal benefits include improved cardiovascular function, limited weight gain and fat retention, easier and less complicated labor, quick recovery, and improved fitness.
- Fetal benefits may include decreased growth of the fat organ, improved stress tolerance, and advanced neurobehavioral maturation.

- Offspring are leaner at age 5 years and have a slightly better neurodevelopmental outcome. Postpubertal effects are still unknown.
- In the absence of medical contraindications, women should be encouraged to maintain their prepregnancy activity level. In general, activity should be individualized (exercise prescription), depending on previous activity levels
- Available outcome data suggest that a healthy woman may begin or maintain a regular exercise regimen during pregnancy, with benefit and without adversely affecting the course and outcome of the pregnancy. Data also suggest that the clear difference between theoretic concern and observed outcome is best explained by the hypothesis that the physiologic adaptations to exercise and to pregnancy are complementary and fetoprotective.
- Although an upper level of safe performance is not established, otherwise healthy mothers-to-be appear to obtain the benefits of a regular exercise regimen without undue risk to the embryo and fetus. The exact regimen can be flexible and individualized (exercise prescription), provided that both the exercise and the pregnancy are monitored.

Osteoporosis

- Exercise is an essential part of treatment for patients with osteoporosis. Just as regular workouts build muscle, these activities also maintain and may even increase bone strength. By strengthening the muscles and bones and improving balance, exercise can reduce the risk of falls and resulting fractures.
- Exercise works well with medications that increase bone density and strength.
- Exercise, medication, and proper diet, including an absorbable source of calcium, phosphorus, boron, and other bone-building minerals, are more effective in combating osteoporosis than any one treatment alone.
- Weight-bearing exercises and resistance training benefit bones and muscles as well as help improve general health.
    - Weight-bearing exercise
        - For most people who have osteoporosis, brisk walking is ideal.
        - Walking can be performed anywhere, requires no special equipment, and carries minimal risk of injury.
        - If walking is too difficult or painful, workouts on a stationary exercise cycle are a good alternative.
    - Resistance training
        - Lifting weights or using strength-training machines strengthens bones, especially if one exercises all of the major muscle groups in the legs, arms, and trunk.
        - A qualified trainer, exercise specialist, or therapist is important for instructing and guiding resistance-training programs.
        - Joining a gym or fitness facility is a good way to begin because these facilities typically provide access to trainers who can advise on proper techniques.
        - Strength training is a slow process, so it should be started at a low level and should be gradually built up over several months. For each exercise, select weights or set the machine so the muscle being trained becomes fatigued after 10-15 repetitions. As muscles strengthen, gradually add more weight. The weight should not be increased more than 10% per week because larger increases can increase the risk of injury.

Tips for trouble-free exercise

- Lift and lower weights slowly to maximize muscle strength and to minimize the risk of injury.
- Perform resistance workouts on any given muscle group every second or third day. This gives your body a chance to recover.
- Avoid exercise that puts excessive stress on the bones, such as running or high-impact aerobics. Rowing is appropriate if proper form is used and the rowing machine provides a way to maintain continuous inertia with the use of a flywheel.
- Stiffness is normal the morning after exercise. If pain continues for most of the following day, joints become swollen, or a limp develops, stop the program until comfortable again and reduce the weight and number of repetitions by 25-50%. If bone, joint, or muscle pain is severe, call the doctor.
- If a particular area of the body feels sore right after exercise, apply ice for 10-15 minutes. Wrap ice in a towel or plastic bag or just hold a cold canned or bottled beverage on the spot.
- Vary the routine to make it more interesting. For example, if the strength-building program involves 12 separate exercises, complete 6 in one session and the other 6 in the next session.

Exercise Prescription for Individuals With Coronary Artery Disease

Physical inactivity is recognized as a risk factor for coronary artery disease. Regular aerobic physical activity increases exercise capacity and plays a role in both primary and secondary prevention of cardiovascular disease.[1,2,3,4,5,6,7,10,11,12,13,14] The known benefits of regular aerobic exercise and recommendations for implementation of exercise programs are discussed.

Exercise training increases cardiovascular functional capacity and decreases myocardial oxygen demand at any level of physical activity in apparently healthy persons and in most individuals with cardiovascular disease. Regular physical activity is required to maintain these training effects. Myocardial work can be affected by caffeine intake, and caffeine intake has been shown to increase blood pressure response to exercise. The potential risks of physical activity can be reduced by receiving a medical evaluation, risk stratification, supervision, and education.

Exercise can help control blood lipid abnormalities, diabetes, and obesity. In addition, aerobic exercise adds an independent blood pressure–lowering effect in certain hypertensive patient groups, with a decrease of 8-10 mm Hg in both systolic and diastolic blood pressure measurements. A direct relationship exists between physical inactivity and cardiovascular mortality, and physical inactivity is an independent risk factor for the development of coronary artery disease. A dose response relationship exists between the amount of exercise performed (from approximately 700-2000 kcal/wk [2940-8400 kJ/wk] energy expenditure) and all-cause mortality and cardiovascular disease mortality in middle-aged and elderly populations.

The greatest potential for reduced mortality is in sedentary persons who become moderately active. Most beneficial effects of physical activity on cardiovascular disease mortality can be attained through moderate-intensity activity (40-60% of maximal VQ, depending on the participant's age). The activity can be accrued through formal training programs or leisure-time physical activities.

Although most supporting data are based on studies in men, relatively recent findings show similar results for women. Results of pooled studies reveal that persons who modify their behavior after myocardial infarction to include regular exercise have improved rates of survival.

Studies have revealed that intensive multiple interventions, such as smoking cessation, blood lipid reduction, weight control, and physical activity, significantly decreased the rate of progression—and,

in some cases, lead to regression—in the severity of atherosclerotic lesions in persons with coronary disease.

In addition, limited data indicate that higher-intensity exercise, compared with lower-intensity exercise, improves left ventricular ejection fractions in persons with coronary artery disease. Current activity status (eg, persons remaining physically active or having been sedentary and becoming physically active) revealed the greatest decline in coronary artery disease risk. Persons who remain sedentary have the highest risk for cardiovascular disease mortality.

Exercise intensity should approximate 40-85% of VO_2 reserve (VO_2 R) or HR reserve (HRR), as determined by an exercise test. If a test is not performed initially, a reasonable estimate of 20-30 beats per minute (bpm) above HR rest is generally appropriate until testing is performed.

Activities can be prescribed according to the work intensity at which the training HR is achieved after 5-10 minutes at the same workload (steady state). This may be expressed as watts on an ergometer, speed on a treadmill, or METs. If an individual cannot assess intensity, HR counting (manually or with a pulse meter or cardiotachometer) is especially useful. HR counters are widely available and generally accurate for low- to moderate-intensity exercise.

If an individual intends to walk on a level surface, activity can be prescribed as the treadmill step rate that generates the desirable HR. The step rate is the number of steps taken in 15 seconds while walking at the desired speed on the treadmill. Step rate can be counted easily because it requires less skill than counting HR. If this approach is used, caution individuals to avoid hills. Walking in shopping malls or gymnasiums allows individuals to avoid inclement weather and to exercise on a flat surface. Exercise should be supervised for the first few sessions to ensure that instructions are understood and the activity is well tolerated.

Individuals can also judge the intensity of exercise by the RPE, which can be equated with the desired HR during laboratory exercise and activities. The original scale is a 15-grade category scale that ranges from 6-20, with a verbal description at every odd number, beginning at 7 (very, very light) and progressing to 19 (very, very hard).

RPE values should be rated as follows:

- Less than 12 – Perceived as fairly light (light intensity), 40-60% of HR_{max}
- From 12-13 – Perceived as somewhat hard (moderate intensity), 60-75% of HR_{max}
- From 14-16 – Perceived as hard (high intensity), 75-90% of HR_{max}

Activities can progress as tolerance is demonstrated. An appropriate initial intensity of training is 60-75% of HR_{max} (moderate) or an RPE of 12-13. However, many individuals may need to begin at 40-60% of HR_{max} (light). After safe activity levels have been established, duration is increased in 5-minute increments each week. Later, with increased strength and as the HR response to exercise decreases with conditioning, intensities can be increased to a frequency of 3-6 times per week. At this point, limited resistive exercises can be added, which have proved both safe and effective in secondary prevention.

Exercise prescription in the presence of ischemia or arrhythmias (moderate to high risk)

An exercise test and medical supervision are essential for this type of exercise prescription. The manifestations of arrhythmias or ischemia that require such precautions can vary but usually include the following:

- Ventricular tachycardia (3-4 beats)

- Any arrhythmia that is symptomatic or causes hemodynamic instability
- Chest discomfort that is believed to be angina
- Significant electrocardiograph (ECG) ST depression
- Inappropriate blood pressure responses such as significant hypertension or a decrease in systolic blood pressure of 20 mm Hg from baseline

Perform exercise testing in the usual fashion, but the conditioning work intensity is derived from the HR associated with the abnormality. If the exercise test continues to a high level of effort, the HR at 50-60% of maximum can be used if it falls at least 10 bpm below the abnormal level. Otherwise, the recommended peak training HR is 10 bpm less than that associated with the abnormality. These individuals are recommended to have medically supervised cardiac rehabilitation and reevaluation to restratify them to a lower risk. Repeat exercise testing at least yearly.

As the population ages and more elderly persons survive coronary events, increasing numbers need appropriate physical activity. Most of these persons initially demonstrate benefits from supervised exercise for a brief period. This is performed primarily to introduce the patient to exercise (which the individual may not have performed before) and to evaluate the patient for possible complications of exercise, such as arrhythmias, evidence of heart failure, anginal chest pain, or abnormal ECG ST segments. On the basis of the evaluation, the person can be categorized as low risk or moderate to high risk, and appropriate cardiac rehabilitation precautions can be taken.

Most individuals in secondary prevention can soon be restratified as low risk and can implement their exercise prescription at home or in a community program. In this setting, the previously mentioned primary prevention guidelines also apply. The intensity may be much less, and the frequency may be more, with appropriate changes in duration. Interval exercise testing is recommended at least yearly, and coronary risk factor modification should be aggressive.

In summary, implementation of physical activity strategies by physicians for both primary and secondary prevention should consider the dosing effect or expenditure of kilocalories or kilojoules over a unit of time (usually a week). The guidelines above ideally should entail 5-6 hours of various physical activities weekly if possible. The exercise routine must be individualized (exercise prescription) and should include both aerobic and resistance activities. The benefits of exercise are enhanced with good to excellent compliance with exercise and appropriate lifestyle modifications.

Postmyocardial infarction

As the safety of early ambulation was progressively demonstrated in patients after suffering myocardial infarction, other benefits were realized, such as the prevention of the deconditioning effects of bed rest, decrease of anxiety and depression, and improved functional status at discharge.

- Early activity
    - Walking is the recommended mode of activity unless the individual can attend supervised classes where other activities are provided. Begin limited walking and slowly continue, with a gradual increase in duration until 5-10 minutes of continuous movement has been achieved. Active but nonresistive range of motion of the upper extremities is also well tolerated early if the activities do not stress or impair healing of the sternal incision in persons who have had coronary bypass surgery.
    - The emphasis of exercise in the first 2 weeks after myocardial infarction or coronary bypass surgery should be on offsetting the effects of bed rest or former periods of inactivity. Begin to increase activity when the individual's condition is stable, as measured by ECG tracings, vital signs, and symptomatic standards. Although the

prescribed activity is usually well tolerated and safe, certain precautions are recommended, such as awareness of chest discomfort, faintness, and dyspnea.
    - Supervise the initial activities and record symptoms, RPE, HR, and blood pressure. When safety and tolerance are documented, the activity can be performed without supervision.
- Late activity
    - A symptom-limited exercise test is often performed after the individual's condition has stabilized (as early as 2-6 wk after the coronary event). In secondary prevention, such testing is essential in all patients before beginning a physical activity program. If more studies (eg, echocardiography, angiography) are not indicated, a regular conditioning program can be initiated with a careful prescription of activity based on results of the exercise test.
    - For conditioning purposes, perform large muscle group activities for at least 20-30 minutes (preceded by a warm-up and followed by cool-down) at least 3-4 times per week. The exercise prescription should be based on the exercise test results.
    - Supervised group sessions are recommended initially to enhance the exercise educational process, ensure that the participant is tolerating the program, confirm progress, and provide medical supervision in high-risk situations.
    - Unsupervised home programs are acceptable for persons who are at low risk and who are motivated and understand the basic principles of exercise training.

Additional Research and Future Issues

The body of knowledge on exercise is large, but data on exercise and its effects on the cardiovascular system and long-term survival are still relatively limited. The responsibility for conducting research lies with government agencies, private health organizations, the insurance industry, employers, universities, and medical schools.

Basic knowledge of the anatomic, biochemical, and physiologic changes that result from various patterns of physical activity (short- and long-term, sustained and intermittent, isotonic and isometric, low and high intensity) in persons of different ages is needed, as is a determination of whether a certain minimum-intensity threshold of physical activity is required for benefit.

The biomedical and economic impact of participation in exercise programs on coronary artery disease, cerebrovascular and peripheral vascular disease, heart failure, and hypertension should also be evaluated. The psychosocial functioning of persons with coronary artery disease and the potential value of exercise in enhancing the quality of life for cardiac and other patients warrants further study. Future studies should include adequate numbers of women, ethnic groups, and elderly persons to better meet research objectives.

Furthermore, the presence and extent of coronary risk factors in disabled and disadvantaged individuals and in minority groups must be identified and better defined. Consequently, the effect of modifications (eg, increases in physical activity on members of these groups) should be explored. Large studies should also include a significant number of these persons.

Research should be continued to establish the cost-effectiveness of physical activity programs for the enhancement of cardiovascular health, with a focus on the type of promotional strategies required for initiating and maintaining physical activity (eg, insurance incentives, health personnel, public policy, media materials) and the social context of such activity (eg, industry and business, rural and urban settings, schools, churches, families). Research should also involve issues such as how physical activity can prevent (or decrease the duration of) the hospitalization of patients with chronic disease.

More information is also needed to identify societal, cultural, ethnic, and personal factors that affect development or maintenance of lifelong patterns of physical activity and incorporation of these into exercise promotion strategies. Research on better and more effective physical activity interventions that improve long-term compliance to a physically active lifestyle is urgently needed. Innovative nontraditional methods of increasing physical activity in the population must be developed, implemented, and evaluated.

In summary, future developments and studies should focus not only on the benefits of physical activity, but also on exercise adherence strategies and the methods used to facilitate dissemination of present and future knowledge to all members of society.

Glossary of Terms

Exercise intensity is generally expressed as a percentage of either HR or VO_2. By definition, VO_2 is the oxygen uptake by an individual at rest or during exertion, expressed commonly in milliliters of oxygen consumed per kilogram body weight per minute (mL/kg/min)

Heart rate reserve (HRR) is defined as the maximal heart rate (HR_{max}) observed during a symptom-limited exercise stress test minus the resting heart rate (HR rest). A percentage of the HRR range is added to the HR rest to determine a target heart rate (THR) range to be used during exercise. This approach accounts for individual variability in the HR rest and better reflects the peak exercise oxygen consumption ($VO_{2\ max}$). $VO_{2\ max}$ reflects the highest rate of oxygen consumption that one can achieve.

Oxygen uptake reserve (VO_2 R) is the difference between resting and maximal VO_2. Previous guidelines suggest exercise prescriptions should be based on the oxygen uptake reserve (VO_2 R) rather than a direct percentage of the $VO_{2\ max}$.[27] Exercise intensities based on VO_2 R are approximately equal to the same percentage values for HRR; therefore, the use of HRR in determining appropriate exercise intensities is suitable in most cases. However, certain exceptions to using this approach may include patients with poor chronotropic responses, dysautonomia, pacemakers, or heart transplantation.

Target heart rate (THR) for exercise is generally recommended from 50% to 85% HRR (or VO_2 R). For deconditioned individuals, 40-50% HRR may be more appropriate for beginning exercise, whereas physically active individuals may require higher intensities to achieve improvements in their conditioning. As an illustration in determining THR, the example below uses a resting HR (RHR) of 70 and a HR_{max} of 180 bpm.

The HRR is 180 – 70, or 110 bpm. Using an average intensity of 60-80% HRR, the THR ranges are calculated (Karvonen approach) as follows:

THR = (HRR × 60%) + RHR;

THR = (110 × 0.60) + 70 = 136 bpm

to

(110 × 0.80) + 70 = 158 bpm

So, a THR range would be 136-158 bpm or a pulse count of 22-26 beats per 10 seconds.

Metabolic equivalents (METs) are useful units when recommending exercise. By definition, 1 MET is the amount of oxygen consumed at rest or about 3.5 mL/kg/min. However, recent studies indicate

that the average resting MET level in subjects with coronary heart disease is 23% to 36% lower than the 3.5 mL/kg/min standard value.[28] Nevertheless, most people walking 2 mph require 2 METs, and 3 mph require 3-4 METs. Published MET tables describe many activities in terms of the estimated MET requirements. For example, if an individual has a $VO_{2\ max}$ of 34 mL/kg/min, the VO_2 R is 34 minus the resting VO_2 of 3.5 mL/kg/min equals 30.5 mL/kg/min. Dividing this result by 3.5 yields 8.7 METs. Using 60-80% VO_2 R, the recommended range of exercise METs may be determined by the following:

(8.7 × 0.60) + 1.0 (resting) = 6.2 METs

to

(8.7 × 0.80) + 1.0 (resting) = 8 METs

When one consults a common MET table, an exercise intensity of 6.2-8.0 METs is equivalent to a slow walk-jog combination exercise, hiking with a backpack, hill climbing, and numerous other moderately vigorous activities.

Exercise intensity may be customized to the individual (exercise prescription) based upon their metabolic response to progressive exercise if the $VO_{2\ max}$ and the **anaerobic threshold (AT)** or **ventilatory threshold (VT)** is determined. By definition, the VT may be described as the level of oxygen consumption (VO_2) at which a significant increase in anaerobiosis occurs, as evidenced by an increase in blood lactate levels and respiratory responses to the increasing exercise workload. MET is a unit of energy or level of oxygen used at rest (1 MET = VO_2 of 3.5 mL/kg/min).

Exertion below the VT can generally be sustained for long time periods; whereas, above the VT, the individual can only tolerate a limited amount of time such as several minutes. As a training principle, exercising at the VT may be optimal due to considerable stimulation with a minimal lactate accumulation. Many recreational as well as high-caliber endurance athletes train above the VT but below the **respiratory compensation (RC)** point. The RC may be described as the point when the CO_2 production is increased in relation to ventilation; typically when the individual no longer has voluntary control over the ventilation (ie, the ventilation is driven by metabolic factors).

Maximal voluntary ventilation (MVV) is defined as the maximal amount of ventilation per minute, generally determined by a 12-second hyperventilation procedure to maximal ventilation capabilities.

The **respiratory exchange ratio (R or RER) or respiratory quotient (RQ)** is the ratio of the VO_2 to the carbon dioxide produced in the body. At rest, the RER reflects the substrate's use of fuel sources (eg, carbohydrates, fats, proteins). The metabolism of fats or fatty acids yields a ratio of 0.7; of carbohydrates, 1; and of protein, 0.84. During exercise, the RER generally exceeds 1 because of the additional carbon dioxide produced as a byproduct of the bicarbonate system and because of lactate buffering.

Borg ratings of perceived exertion

The RPE scale is used widely in exercise science and sports medicine to monitor or prescribe levels of exercise intensity. The 95%-limits-of-agreement technique has been advocated as a better means of assessing within-subject (trial-to-trial) agreement.

The perception of exertion is a monitoring behavior that uses all sources of information to govern actions that can benefit or preserve health and partake of adaptive pursuits. How a person feels about exertion moderates his or her response to exercise and effort. The perception of what is happening in exercise, and its concomitant effect on physiologic function, must be known to further

understand the nature of an exercise response. How a person feels modifies reactions to exercise stress and the mechanisms that underlie them.

Exercise is never a purely mechanistic physiologic reaction. The interpretation of the exercise experience governs the nature, quality, and extent of the exercise response. To fully understand and accurately assess the nature of an exercise behavior, measuring as many moderating variables as possible is necessary.

Physiologic measures can be used to grade the strain for each individual, but so can exertion estimates. In an exercise response, the underlying determining mechanism may not be the pure physiologic parameter being measured. Without knowledge of the psychologic moderator variables, the physiologic measurement alone is misleading; its value as a predictor variable is usually negligible. The particular circumstances in which the physiologic measurement is taken may be more important for predicting or analyzing a response than the variable itself. To exercise only according to HR is dangerous. The aches and strain that are felt may be very important indicators of the real degree of exertion. Rigid adherence to the objective measures of physiology may cause interpretive and prescriptive errors of great magnitude.

In many circumstances, the psychologic components of an exercise response are more reliable and relevant than the physiologic measures. This has been shown to be true in the assessment of long-term exercise strain for determining the early symptoms of overtraining or maladaptation.

Borg's original intention was to construct a category scale from 6-20 in which scale levels were roughly one tenth of the HR for equivalent scaled exercise levels. A score of 6 (no exertion at all) should exhibit an HR somewhere in the vicinity of 60 bpm for a young to middle-aged, mildly fit individual. This correspondence is generally reserved for middle-aged people exercising at moderate to high intensity levels. At best, this is a very rough estimation of the relationship; individual variability is significant. Also, the relationship between HR and RPE within an individual varies with different forms of activity. The RPE is best reserved for intraindividual comparisons for a specific form of exercise.

HRs are related linearly to the scale scores ($r = 0.8\text{-}0.9$). However, even with this relationship one cannot conclude that HR is a cause of the perceived exertion.

The perception of exertion integrates many more exercise factors than are considered with singular or isolated physiologic variables. This integration is a truer indication of an exercise response than is depicted by restricted variables such as HRs, lactate measurements, or blood measurements. To understand a certain RPE value, knowing (1) the age and other personal characteristics of the individual, (2) what type of activity was performed, and (3) the environmental conditions that existed at the time is important. The instructions for using the scale are to "estimate how hard and strenuous you feel the work to be." The perception should be general, rather than focusing on specific parts of the body (eg, "tired arms"). The perception of exertion should include as many contributory sensations as possible.

Once the verbal description is determined, the individual should choose an exact number that corresponds to the verbal descriptor. When a subject is unable to complete the highest workload, the rating should be of the work at the time of the final interruption. With athletes, the major problem with using RPE is their common tendency to underestimate the exertion level. Practice in using the scale is necessary. If the various categories can be aligned with other categories or levels of work response, an accurate level of discrimination can be developed between the categories. The RPE yields important additional data beyond those available through isolated physiologic variables. In conscientious and reliable individuals, its value exceeds that of singular parameters of performance.

Instructions for use:

During the exercise you are to rate your perception of exertion. Use this scale, where 6 means no exertion at all, and 20 means a totally maximum effort. The 13 on the scale is a somewhat heavy exercise but capable of being performed at steady state (ie, anaerobic threshold). When at a level of 17, the effort level requires you to push yourself hard even though it is possible to continue for some time. For many people, 19 is about as strenuous as exercise becomes because they often reserve a small amount of possible extra effort. Try to appraise the feeling of exertion as honestly as possible. Do not underestimate or overestimate it. It is of no value to underestimate the level to produce an impression of being brave or tough. Your own feeling of effort and exertion is all that is of interest. Look at the scale and wordings and decide on the word that best describes your effort level and the number alternative associated with that description.

The Borg scale is as follows:

- 6 – No exertion at all
- 7-8 – Extremely light (very, very light)
- 9-10 – Very light (A1 warm-up/recovery)
- 11 – Light (A2 aerobic threshold)
- 12-13 – Moderate (EN-1 anaerobic threshold)
- 14-15 – Hard (EN-2 $VO_{2\ max}$ or 400-m swimming pace)
- 16-17 – Very hard (AN-1 peak lactate or lactate tolerance, 200-m swimming pace)
- 18-19 – Extremely hard (very, very hard [AN-2 anaerobic power, 25-50–m swimming pace])
- 20 – Maximum all-out effort, with absolutely nothing being held in reserve

References

1. Balady GJ, Williams MA, Ades PA, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. *Circulation*. May 22 2007;115(20):2675-82. [Medline]. [Full Text].

2. Talbot LA, Morrell CH, Fleg JL, Metter EJ. Changes in leisure time physical activity and risk of all-cause mortality in men and women: The Baltimore Longitudinal Study of Aging. *Prev Med*. Aug-Sep 2007;45(2-3):169-76. [Medline].

3. Taylor NF, Dodd KJ, Shields N, Bruder A. Therapeutic exercise in physiotherapy practice is beneficial: a summary of systematic reviews 2002-2005. *Aust J Physiother*. 2007;53(1):7-16. [Medline]. [Full Text].

4. The President's Council on Physical Fitness and Sports. Physical activity and health. A report of the Surgeon General, US Department of Health and Human Services, Center for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion. Centers for Disease Control and Prevention. Available at http://www.cdc.gov/nccdphp/sgr/sgr.htm. Accessed September 12, 2007.

5. American College of Sports Medicine. *ACSM's Guidelines for Exercise Testing and Prescription*. 7th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2006.

6. American College of Sports Medicine. *ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription*. 5th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2006.

7. Fletcher GF, Balady G, Blair SN, et al. Statement on exercise: benefits and recommendations for physical activity programs for all Americans. A statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart Association. *Circulation*. Aug 15 1996;94(4):857-62. [Medline]. [Full Text].

8. Knuttgen HG. Strength training and aerobic exercise: comparison and contrast. *J Strength Cond Res*. Aug 2007;21(3):973-8. [Medline].

9. Jeon CY, Lokken RP, Hu FB, van Dam RM. Physical activity of moderate intensity and risk of type 2 diabetes: a systematic review. *Diabetes Care*. Mar 2007;30(3):744-52. [Medline]. [Full Text].

10. Laukkanen JA, Rauramaa R, Salonen JT, Kurl S. The predictive value of cardiorespiratory fitness combined with coronary risk evaluation and the risk of cardiovascular and all-cause death. *J Intern Med*. Aug 2007;262(2):263-72. [Medline].

11. Smith SC Jr, Allen J, Blair SN. AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease: 2006 update endorsed by the National Heart, Lung, and Blood Institute. *J Am Coll Cardiol*. May 16 2006;47(10):2130-9. [Medline]. [Full Text].

12. Wenger NK, Froelicher ES, Smith LK, et al. Cardiac rehabilitation as secondary prevention. Agency for Health Care Policy and Research and National Heart, Lung, and Blood Institute. *Clin Pract Guidel Quick Ref Guide Clin*. Oct 1995;17:1-23. [Medline]. [Full Text].

13. Smith SC Jr, Blair SN, Criqui MH, et al. Preventing heart attack and death in patients with coronary disease. *Circulation*. Jul 1 1995;92(1):2-4. [Medline].

14. Health and Public Policy Committee, American College of Physicians. Cardiac rehabilitation services. *Ann Intern Med*. Oct 15 1988;109(8):671-3. [Medline].

15. [Best Evidence] Kodama S, Saito K, Tanaka S, et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. *JAMA*. May 20 2009;301(19):2024-35. [Medline].

16. Dugan SA. Exercise for health and wellness at midlife and beyond: balancing benefits and risks. *Phys Med Rehabil Clin N Am*. Aug 2007;18(3):555-75, xi. [Medline].

17. Myers J, Hadley D, Oswald U, et al. Effects of exercise training on heart rate recovery in patients with chronic heart failure. *Am Heart J*. Jun 2007;153(6):1056-63. [Medline].

18. Deruelle F, Nourry C, Mucci P, et al. Optimal exercise intensity in trained elderly men and women. *Int J Sports Med*. Jul 2007;28(7):612-6. [Medline].

19. Blair SN, Kohl HW 3rd, Barlow CE, et al. Changes in physical fitness and all-cause mortality. A prospective study of healthy and unhealthy men. *JAMA*. Apr 12 1995;273(14):1093-8. [Medline].

20. Lee IM, Hsieh CC, Paffenbarger RS Jr. Exercise intensity and longevity in men. The Harvard Alumni Health Study. *JAMA*. Apr 19 1995;273(15):1179-84. [Medline].

21. Coats AJ, Adamopoulos S, Radaelli A, et al. Controlled trial of physical training in chronic heart failure. Exercise performance, hemodynamics, ventilation, and autonomic function. *Circulation*. Jun 1992;85(6):2119-31. [Medline]. [Full Text].

22. Duncombe D, Skouteris H, Wertheim EH, et al. Vigorous exercise and birth outcomes in a sample of recreational exercisers: a prospective study across pregnancy. *Aust N Z J Obstet Gynaecol*. Aug 2006;46(4):288-92. [Medline].

23. Kramer MS, McDonald SW. Aerobic exercise for women during pregnancy. *Cochrane Database Syst Rev*. 2006;3:CD000180. [Medline].

24. Clapp JF 3rd. Exercise during pregnancy. A clinical update. *Clin Sports Med*. Apr 2000;19(2):273-86. [Medline].

25. Clapp JF 3rd, Simonian S, Lopez B, Appleby-Wineberg S, Harcar-Sevcik R. The one-year morphometric and neurodevelopmental outcome of the offspring of women who continued to exercise regularly throughout pregnancy. *Am J Obstet Gynecol*. Mar 1998;178(3):594-9. [Medline].

26. Clapp JF 3rd. A clinical approach to exercise during pregnancy. *Clin Sports Med*. Apr 1994;13(2):443-58. [Medline].

27. Swain DP, Leutholtz BC. Heart rate reserve is equivalent to %VO2 reserve, not to %VO2max. *Med Sci Sports Exerc*. Mar 1997;29(3):410-4. [Medline].

28. Savage, PD; Toth, MJ and Ades, PA. A re-examination of the metabolic equivalent concept in individuals with coronary heart disease. *Journal of Cardiopulmonary Rehabilitation and Prevention*. May-Jun/ 2007;27:143-148. [Medline].

29. Brockie J. Exercise for women in the early postmenopausal years. *J Br Menopause Soc*. Sep 2006;12(3):126-7. [Medline].

30. Marles A, Legrand R, Blondel N, et al. Effect of high-intensity interval training and detraining on extra VO2 and on the VO2 slow component. *Eur J Appl Physiol*. Apr 2007;99(6):633-40. [Medline].

31. Suleman A, Sung BH, Ajmal M, et al. Caffeine and its effects on the heart: facts, myths, and controversies [no longer available online]. *Life and Medical Sciences Online (Wiesbaden, Germany)*. Apr 2000;1.

32. Yoon BK, Kravitz L, Robergs R. VO2max, protocol duration, and the VO2 plateau. *Med Sci Sports Exerc*. Jul 2007;39(7):1186-92. [Medline].

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