AMERICAN COLLEGE of SPORTS MEDICINE®

POSITION STAND

Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise

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SUMMARY

The purpose of this Position Stand is to provide guidance to professionals who counsel and prescribe *individualized* exercise to apparently healthy adults of all ages. These recommendations also may apply to adults with certain chronic diseases or disabilities, when appropriately evaluated and advised by a health professional. This document supersedes the 1998 American College of Sports Medicine (ACSM) Position Stand, "The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults." The scientific evidence demonstrating the beneficial effects of exercise is indisputable, and the benefits of exercise far outweigh the risks in most adults. A program of regular exercise that includes cardiorespiratory, resistance, flexibility, and neuromotor exercise training *beyond* activities of daily living to improve and maintain physical fitness and health is *essential* for most adults. The ACSM recommends that most adults engage in moderate-intensity cardiorespiratory exercise training for ≥30 min·d^{-1} on ≥5 d·wk^{-1} for a total of ≥150 min·wk^{-1}, vigorous-intensity cardiorespiratory exercise training for ≥20 min·d^{-1} on ≥3 d·wk^{-1} (≥75 min·wk^{-1}), or a combination of moderate- and vigorous-intensity exercise to achieve a total energy expenditure of ≥500–1000 MET·min·wk^{-1}. On 2–3 d·wk^{-1}, adults should also perform resistance exercises for each of the major muscle groups, and neuromotor exercise involving balance, agility, and coordination. Crucial to maintaining joint range of movement, completing a series of flexibility exercises for each the major muscle–tendon groups (a total of 60 s per exercise) on ≥2 d·wk^{-1} is recommended. The exercise program should be modified according to an individual's habitual physical activity, physical function, health status, exercise responses, and stated goals. Adults who are unable or unwilling to meet the exercise targets outlined here still can benefit from engaging in amounts of exercise *less than* recommended. In addition to exercising regularly, there are health benefits in concurrently reducing total time engaged in sedentary pursuits and also by interspersing frequent, short bouts of standing and physical activity between periods of sedentary activity, even in physically active adults. Behaviorally based exercise interventions, the use of behavior change strategies, supervision by an experienced fitness instructor, and exercise that is pleasant and enjoyable can improve adoption and adherence to prescribed exercise programs. Educating adults about and screening for signs and symptoms of CHD and gradual progression of exercise intensity and volume may reduce the risks of exercise. Consultations with a medical professional and diagnostic exercise testing for CHD are useful when clinically indicated but are not recommended for universal screening to enhance the safety of exercise.
Key Words: Practice Guidelines, Prescription, Physical Activity, Physical Fitness, Health, Aerobic Exercise, Resistance Exercise, Flexibility Exercise, Neuromotor Exercise, Functional Fitness

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INTRODUCTION

Many recommendations for exercise and physical activity by professional organizations and government agencies have been published since the *sui generis* publications of the American College of Sports Medicine (ACSM) (10,11). The number of recommendations has escalated after the release of the 1995 Centers for Disease Control and Prevention (CDC)/ACSM public health recommendations (280) and the 1996 US Surgeon General's Report (371), and the ostensibly contradictory recommendations between these documents have led to confusion among health professionals, fitness professionals, and the public (32,155). The more recent recommendations of the American Heart Association (AHA) and the ACSM (155,264) and the *2008 Physical Activity Guidelines for Americans* (370) have helped clarify public health recommendations for physical activity, and these are now are incorporated into the current edition of the *ACSM's Guidelines for Exercise Testing and Prescription* (14). The purpose of this Position Stand is to provide scientific evidence-based recommendations to health and fitness professionals in the development of *individualized* exercise prescriptions for apparently healthy adults of all ages. When appropriately evaluated and advised by a health professional (e.g., physician, clinical exercise physiologist, nurse), these recommendations may also apply to persons with certain chronic diseases or disabilities, with modifications required according to an individual's habitual physical activity, physical function, health status, exercise response, and stated goals. The advice presented in this Position Stand is intended principally for adults whose goal is to improve physical fitness and health; adult athletes engaging in competitive sports and advanced training regimens can benefit from more advanced training techniques (13,212,254,255). The evidence statements and summary exercise recommendations derived from the scientific review are found in Tables 1 and 2.

This document updates the scientific evidence published since the 1998 Position Stand (12). Epidemiological studies, randomized and nonrandomized clinical trials, meta-analyses, evidence-based guidelines, consensus statements, and scientific reviews published from 1998 to 2010 were identified through bibliographic searches using common computer search engines (e.g., PubMed, Medline, Google Scholar, IndexCat, PsychArticles, and CINAHL). References cited in the 2008 *Physical Activity Guidelines Advisory Committee Report* (372), the AHA/ACSM public health statements (155,264), and article bibliographies were also reviewed by the writing group.

Interpretation of the available scientific evidence was made by consensus of the writing group members using the evidence rating system of the National Heart Lung and Blood Institute (263) shown in Table 3. Observational studies of physical activity and, to a lesser extent, physical fitness are the primary sources of data supporting the benefits of exercise in reducing the risks of mortality and morbidity, and these studies provided guidance on the recommended patterns and volumes of exercise to gain health and fitness benefits. Randomized clinical trials of exercise training and meta-analyses contributed evidence for the causal effects (effectiveness and efficacy) of exercise training (frequency, intensity, duration, mode, pattern, volume) for improving physical fitness and biomarkers of chronic disease.

The focus of the recommendations in this Position Stand is on *exercise*, which connotes *intentional* physical activity for improving health and fitness. The terms *physical activity* and *physical fitness* are used when these terms more precisely reflect the nature of the scientific evidence that supports the exercise recommendations. The data supporting the benefits of exercise have been derived primarily from observational studies that have evaluated *physical activity*, or less commonly, *physical fitness* (rather than exercise), while the randomized clinical trials center mostly on *exercise*. Exercise, physical activity, and physical fitness are closely related constructs, but they have distinct meanings. Table 4 presents the definitions of these and other common terms used in this Position Stand. All terms used in this document conform with the definitions found in the *Physical Activity Guidelines Advisory Committee Report* (372) and the classifications of cardiovascular diseases (CVD) of the AHA (229).

WHAT ARE THE HEALTH BENEFITS OF PHYSICAL ACTIVITY AND EXERCISE IN ADULTS?

Regular physical activity and exercise are *associated* with numerous physical and mental health benefits in men and

TABLE 1. Summary of the general evidence relevant to the exercise prescription.

	Evidence Statement	Evidence Category
Health benefits	Engaging in regular exercise and reducing sedentary behavior is vital for the health of adults.	A
Reversibility of training effects	Training-induced adaptations are reversed to varying degrees over time upon cessation of a program of regular exercise.	A
Heterogeneity of response	There is considerable variability in individual responses to a standard dose of exercise.	A
Exercise regimen	Cardiorespiratory and resistance exercise training is recommended to improve physical fitness and health.	A
	Flexibility exercises improve and maintain and joint range of movement	A
	Neuromotor exercises and multifaceted activities (such as tai ji and yoga) can improve or maintain physical function, and reduce falls in older persons at risk for falling.	B
	Neuromotor exercises may benefit middle aged and younger adults	D
Exercise adoption and maintenance	Theory-based exercise interventions can be effective in improving adoption and short-term adherence to exercise.	B
	Moderate-intensity exercise and exercise that is enjoyable can enhance the affective responses to exercise, and may improve exercise adherence	B
	Supervision by an experienced health and fitness professional and enhance exercise adherence	C
Risks of exercise	Exercise is associated with an increased risk of musculoskeletal injury and adverse CHD events.	B
	The benefits of exercise far outweigh the risks in most adults.	C
	Warm-up, cool down, flexibility exercise, and gradual progression of exercise volume and intensity may reduce the risk of CVD events and musculoskeletal injury during exercise.	C
	Consultation with a physician and diagnostic exercise testing for CHD may reduce risks of exercise if medically indicated, but are not recommended on a routine basis.	C
	Consultation with a well-trained fitness professional may reduce risks in novice exercisers and in persons with chronic diseases and conditions	D
Preexercise screening	Screening for and educating about the forewarning signs or symptoms of CVD events may reduce the risks of serious untoward events.	C

Table evidence categories: A, randomized controlled trials (rich body of data); B, randomized controlled (limited body of data); C, nonrandomized trials, observational studies; D, panel consensus judgment. From the National Heart Lung and Blood Institute (263).

TABLE 2. Evidence statements and summary of recommendations for the individualized exercise prescription.

	Evidence-Based Recommendation	Evidence Category
Cardiorespiratory ("aerobic") exercise		
Frequency	≥5 d·wk^{-1} of moderate exercise, or ≥3 d·wk^{-1} of vigorous exercise, or a combination of moderate and vigorous exercise on ≥3–5 d·wk^{-1} is recommended.	A
Intensity	Moderate and/or vigorous intensity is recommended for most adults.	A
	Light- to moderate-intensity exercise may be beneficial in deconditioned persons.	B
Time	30–60 min·d^{-1} (150 min·wk^{-1}) of purposeful moderate exercise, or 20–60 min·d^{-1} (75 min·wk^{-1}) of vigorous exercise, or a combination of moderate and vigorous exercise per day is recommended for most adults.	A
	<20 min·d^{-1} (<150 min·wk^{-1}) of exercise can be beneficial, especially in previously sedentary persons.	B
Type	Regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature is recommended.	A
Volume	A target volume of ≥500–1000 MET·min·wk^{-1} is recommended.	C
	Increasing pedometer step counts by ≥2000 steps per day to reach a daily step count ≥7000 steps per day is beneficial.	B
	Exercising below these volumes may still be beneficial for persons unable or unwilling to reach this amount of exercise.	C
Pattern	Exercise may be performed in one (continuous) session per day or in multiple sessions of ≥10 min to accumulate the desired duration and volume of exercise per day.	A
	Exercise bouts of <10 min may yield favorable adaptations in very deconditioned individuals.	B
	Interval training can be effective in adults.	B
Progression	A gradual progression of exercise volume by adjusting exercise duration, frequency, and/or intensity is reasonable until the desired exercise goal (maintenance) is attained.	B
	This approach may enhance adherence and reduce risks of musculoskeletal injury and adverse CHD events.	D
Resistance exercise		
Frequency	Each major muscle group should be trained on 2–3 d·wk^{-1}.	A
Intensity	60%–70% of the 1RM (moderate to hard intensity) for novice to intermediate exercisers to improve strength.	A
	≥80% of the 1RM (hard to very hard intensity) for experienced strength trainers to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) for older persons beginning exercise to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) may be beneficial for improving strength in sedentary persons beginning a resistance training program.	D
	<50% of the 1RM (light to moderate intensity) to improve muscular endurance.	A
	20%–50% of the 1RM in older adults to improve power.	B
Time	No specific duration of training has been identified for effectiveness.	
Type	Resistance exercises involving each major muscle group are recommended.	A
	A variety of exercise equipment and/or body weight can be used to perform these exercises.	A
Repetitions	8–12 repetitions is recommended to improve strength and power in most adults.	A
	10–15 repetitions is effective in improving strength in middle aged and older persons starting exercise	A
	15–20 repetitions are recommended to improve muscular endurance	A
Sets	Two to four sets are the recommended for most adults to improve strength and power.	A
	A single set of resistance exercise can be effective especially among older and novice exercisers.	A
	≤2 sets are effective in improving muscular endurance.	A
Pattern	Rest intervals of 2–3 min between each set of repetitions are effective.	B
	A rest of ≥48 h between sessions for any single muscle group is recommended.	A
Progression	A gradual progression of greater resistance, and/or more repetitions per set, and/or increasing frequency is recommended.	A
Flexibility exercise		
Frequency	≥2–3 d·wk^{-1} is effective in improving joint range of motion, with the greatest gains occurring with daily exercise.	B
Intensity	Stretch to the point of feeling tightness or slight discomfort.	C
Time	Holding a static stretch for 10–30 s is recommended for most adults.	C
	In older persons, holding a stretch for 30–60 s may confer greater benefit.	C
	For PNF stretching, a 3- to 6-s contraction at 20%–75% maximum voluntary contraction followed by a 10- to 30-s assisted stretch is desirable.	B
Type	A series of flexibility exercises for each of the major muscle–tendon units is recommended.	B
	Static flexibility (active or passive), dynamic flexibility, ballistic flexibility, and PNF are each effective.	B
Volume	A reasonable target is to perform 60 s of total stretching time for each flexibility exercise.	B
Pattern	Repetition of each flexibility exercise two to four times is recommended-	B
	Flexibility exercise is most effective when the muscle is warmed through light to moderate aerobic activity or passively through external methods such as moist heat packs or hot baths.	A
Progression	Methods for optimal progression are unknown.	
Neuromotor exercise training		
Frequency	≥2–3 d·wk^{-1} is recommended.	B
Intensity	An effective intensity of neuromotor exercise has not been determined.	
Time	≥20–30 min·d^{-1} may be needed.	B
Type	Exercises involving motor skills (e.g., balance, agility, coordination, and gait), proprioceptive exercise training, and multifaceted activities (e.g., tai ji and yoga) are recommended for older persons to improve and maintain physical function and reduce falls in those at risk for falling.	B
	The effectiveness of neuromuscular exercise training in younger and middle-aged persons has not been established, but there is probable benefit.	D
Volume	The optimal volume (e.g., number of repetitions, intensity) is not known.	
Pattern	The optimal pattern of performing neuromotor exercise is not known.	
Progression	Methods for optimal progression are not known.	

Table evidence categories: A, randomized controlled trials (rich body of data); B, randomized controlled trials (limited body of data); C, nonrandomized trials, observational studies; D, panel consensus judgment. From the National Heart Lung and Blood Institute (263).

SPECIAL COMMUNICATIONS

TABLE 3. Evidence categories.

Evidence Category	Sources of Evidence	Definition
A	Randomized controlled trials (RCT; rich body of data)	Evidence is from end points of well-designed RCT (or trials that depart only minimally from randomization) that provide a consistent pattern of findings in the population for which the recommendation is made. Category A therefore requires substantial numbers of studies involving substantial numbers of participants.
B	Randomized controlled trials (limited body of data)	Evidence is from end points of intervention studies that include only a limited number of RCT, *post hoc* or subgroup analysis of RCT, or meta-analysis of RCT. In general, Category B pertains when few randomized trials exist, they are small in size, and the trial results are somewhat inconsistent, or the trials were undertaken in a population that differs from the target population of the recommendation.
C	Nonrandomized trials, observational studies	Evidence is from outcomes of uncontrolled or nonrandomized trials or from observational studies.
D	Panel consensus judgment	Expert judgment is based on the panel's synthesis of evidence from experimental research described in the literature and/or derived from the consensus of panel members based on clinical experience or knowledge that does not meet the above-listed criteria. This category is used only in cases where the provision of some guidance was deemed valuable but an adequately compelling clinical literature addressing the subject of the recommendation was deemed insufficient to justify placement in one of the other categories (A through C).

Evidence categories reprinted with permission from the National Heart Lung and Blood Institute (263).

women. All-cause mortality is delayed by regularly engaging in physical activity; this is also the case when an individual *increases* physical activity by changing from a sedentary lifestyle or a lifestyle with insufficient levels of physical activity to one that achieves recommended physical activity levels (372). Exercise and physical activity decrease the risk of developing CHD, stroke, type 2 diabetes, and some forms of cancer (e.g., colon and breast cancers) (372).

Exercise and physical activity lower blood pressure; improve lipoprotein profile, C-reactive protein, and other CHD biomarkers; enhance insulin sensitivity, and play an important role in weight management (372). Of particular relevance to older adults, exercise preserves bone mass and reduces the risk of falling (264). Prevention of and improvement in mild to moderate depressive disorders and anxiety can occur with exercise (35,155,244,250,305,337,398). A physically active lifestyle enhances feelings of "energy" (294), well-being (25,406), quality of life (81,139,302), and cognitive function (203,318,333) and is associated with a lower risk of cognitive decline and dementia (210,281,387,405).

WHAT ARE THE HEALTH BENEFITS OF PHYSICAL FITNESS?

Each component of physical fitness (i.e., cardiorespiratory fitness, muscular strength and endurance (muscular fitness), body composition, flexibility, and neuromotor fitness) conceivably influences some aspect of health. Quantitative data on the relationships between fitness and health are available for only some fitness components, with the most data available on body composition and cardiorespiratory fitness. In the domain of body composition, overall and abdominal obesity are associated with increased risk of adverse health outcomes (12,37,92,301), whereas greater fat-free mass is associated with a lower risk of all-cause mortality (37,160). Higher levels of cardiorespiratory and muscular fitness are each associated with lower risks for poorer health (24,42,75,117,128,189,265,292,339).

Relationships between cardiorespiratory fitness, biological risk factors, and clinical health outcomes tend to parallel those for physical activity: apparently healthy middle-aged and older adults with greater cardiorespiratory fitness at

TABLE 4. Definition of key terms.

Active commuting	Traveling to or from work or school by a means involving physical activity, such as walking, riding a bicycle (324).
Biomarkers	A specific biochemical indicator of a biological process, event, or condition (i.e., disease, aging, etc.) (251).
Cardiometabolic	Factors associated with increased risk of CVD and metabolic abnormalities including obesity, insulin resistance, glucose intolerance, and type 2 diabetes mellitus.
Physical activity	"Any bodily movement produced by skeletal muscles that results in energy expenditure" (64) above resting (basal) levels (371). Physical activity broadly encompasses exercise, sports, and physical activities done as part of daily living, occupation, leisure, and active transportation.
Exercise	"Physical activity that is planned, structured, and repetitive and [that] has as a final or intermediate objective the improvement or maintenance of physical fitness" (64).
Physical fitness	"The ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy [leisure] pursuits and to meet unforeseen emergencies" (64). Physical fitness is operationalized as "[a set of] measurable health and skill-related attributes" that include cardiorespiratory fitness, muscular strength and endurance, body composition and flexibility, balance, agility, reaction time and power (1985).
Physical function	The capacity of an individual to carry out the physical activities of daily living. Physical function reflects motor function and control, physical fitness, and habitual physical activity (54,176) and is an independent predictor of functional independence (130), disability (126), morbidity, and mortality (125).
Energy expenditure	The total amount of energy (gross) expended during exercise, *including* the resting energy expenditure (resting energy expenditure + exercise energy expenditure). Energy expenditure may be articulated in METs, kilocalories or kilojoules (342).
MET	An index of energy expenditure. "[A MET is] the ratio of the rate of energy expended during an activity to the rate of energy expended at rest…. [One] MET is the rate of energy expenditure while sitting at rest…by convention, [1 MET is equal to] an oxygen uptake of 3.5 [$mL \cdot kg^{-1} \cdot min^{-1}$]" (370).
MET-minutes	An index of energy expenditure that quantifies the total amount of physical activity performed in a standardized manner across individuals and types of activities (370). Calculated as the product of the number of METs associated with one or more physical activities and the number of minutes the activities were performed (i.e., METs $\times$ minutes). Usually standardized per week or per day. Example: jogging (at ~7 METs) for 30 min on 3 $d \cdot wk^{-1}$: 7 METs $\times$ 30 min $\times$ three times per week = 630 $MET \cdot min \cdot wk^{-1}$.
Sedentary behavior	Activity that involves little or no movement or physical activity, having an energy expenditure of about 1–1.5 METs. Examples are sitting, watching television, playing video games, and using a computer (276).

baseline, and those who improve fitness over time have a lower risk of all-cause and CVD mortality and morbidity (41,213,339,340). A decreased risk of clinical events is also associated with greater cardiorespiratory fitness in individuals with preexisting disease (75,213,247,262,338).

The minimum level of cardiorespiratory fitness required for health benefit may be different for men and women and for older and younger adults. This is because the distribution of cardiorespiratory fitness is different between healthy men and women (14) and a nonlinear decline in cardiorespiratory fitness, which occurs with advancing age when not accompanied by a program of regular exercise (118). Sex- and age-specific norms for cardiorespiratory fitness in apparently healthy adults are available in the *ACSM Guidelines for Exercise Testing and Prescription* (14).

HOW MUCH PHYSICAL ACTIVITY IS NEEDED TO IMPROVE HEALTH AND CARDIORESPIRATORY FITNESS?

What volume of physical activity is needed? Several studies have supported a dose–response relationship between chronic physical activity levels and health outcomes (155,372), such that greater benefit is associated with higher amounts of physical activity. Data regarding the specific quantity and quality of physical activity for the attainment of the health benefits are less clear. Epidemiologic studies have estimated the *volume* of physical activity needed to achieve specific health benefits, typically expressed as kilocalories per week (kcal·wk^{-1}), MET-minutes per week (MET·min·wk^{-1}), or MET-hours per week (MET·h·wk^{-1}). Large prospective cohort studies of diverse populations (216,237,320,353) clearly show that an energy expenditure of approximately 1000 kcal·wk^{-1} of moderate-intensity physical activity (or about 150 min·wk^{-1}) is associated with lower rates of CVD and premature mortality. This is equivalent to an intensity of about 3–5.9 METs (for people weighing ~68–91 kg) and 10 MET·h·wk^{-1}. Ten MET-hours per week can also be achieved with ≥20 min·d^{-1} of vigorous-intensity (≥~6 METs) physical activity performed ≥3 d·wk^{-1} or for a total of ~75 min·wk^{-1}. Previous investigations have suggested that there may be a dose–response relationship between energy expenditure and depression, but additional study is needed to confirm this possibility (25,101).

In the general population, this 1000 kcal·wk^{-1} volume of physical activity is accumulated through a combination of physical activities and exercise of varying intensities. Therefore, the *2008 Physical Activity Guidelines for Americans* (370), the 2007 AHA/ACSM recommendations (155,264), and the ACSM guidelines (14) allow for a combination of moderate- and vigorous-intensity activities to expend the requisite weekly energy expenditure. An intriguing observation from several studies is that significant risk reductions for CVD disease and premature mortality begin to be observed at volumes *below* these recommended targets, starting at about *one-half* of the recommended volume (i.e., ~500 kcal·wk^{-1}) (214,237,320,353). This observation is congruent with the findings from the DREW trial (76) among sedentary, overweight postmenopausal women, which showed that one-half the currently recommended volume of physical activity was sufficient to significantly improve cardiorespiratory fitness.

The available data support a dose–response relationship between physical activity and health outcomes, so it is reasonable to state with respect to exercise, ''some is good; more is better.'' However, the shape of the dose–response curve is less clear, and it is probable that the shape of the curve may differ depending on the health outcome of interest and the baseline level of physical activity of the individual (155).

***How* can studies of physical fitness help to clarify the question of "*How* much physical activity is needed?"** The physical activity dose required to achieve a specific health benefit may be further clarified by equating specific amounts of physical activity to the levels of cardiorespiratory fitness sufficient to confer health benefits. For instance, a study of apparently healthy middle-aged adults (335) showed that all-cause and CVD mortality rates were approximately 60% lower in persons with moderate compared with low cardiorespiratory fitness, estimated from time to fatigue on a treadmill test. The adults of moderate fitness in this study reported a weekly energy expenditure in moderate-intensity physical activity, such as brisk walking on level ground, of ~8–9 MET·h·wk^{-1}. Therefore, a level of cardiorespiratory fitness associated with substantial health benefit seems to be attainable through a dose of exercise or physical activity compatible with the recommendations in this Position Stand and other current publications (14,155,264,370).

WHAT IS THE EFFECT OF EXERCISE TRAINING ON CARDIORESPIRATORY FITNESS AND CARDIOVASCULAR AND METABOLIC DISEASE (CARDIOMETABOLIC) RISK FACTORS?

What is the role of exercise intensity in modifying the responses to exercise? Either moderate- or vigorous-intensity exercise, or both, can be undertaken to meet current exercise recommendations, provided the criterion for total volume of energy expended is satisfied. What is less clear is this: for the same volume of energy expended, is vigorous-intensity exercise associated with additional risk reduction? The data are unclear because most epidemiologic studies examining chronic disease outcomes and randomized clinical trials of exercise training have not taken into account the total volume of energy expended (323). That is, in most studies where benefit is found for vigorous- compared with moderate-intensity exercise, there is also a greater volume of exercise in the vigorous-intensity condition. Thus, it is unclear whether the added benefit is due to the vigorous-intensity *per se* or whether the results simply reflect the additional benefit due to the higher *volume* of energy expended. Nevertheless, there are some reports that support that vigorous-intensity exercise is associated with greater risk reductions for CVD and all-cause mortality compared with moderate-intensity activity of similar energy expended (155).

Exercise intensity *is* an important determinant of the physiological responses to exercise training (12,14,120). Earlier randomized trials did not control for total exercise volume, so the *independent* contributions of volume and intensity were unclear, but more recent studies have supported the greater benefits of vigorous versus moderate exercise. DiPietro et al. (97) found significant improvements in glucose utilization in sedentary older men and women who engaged in vigorous (80% maximal oxygen uptake ($\dot{V}O_{2max}$)) exercise but not in those who performed moderate (65%$\dot{V}O_{2max}$) exercise, although all subjects expended 300 $kcal{\cdot}d^{-1}$ on 4 $d{\cdot}wk^{-1}$. A comprehensive review by Swain (343) concluded that there were greater improvements in $\dot{V}O_{2max}$ with vigorous-intensity exercise training compared with moderate-intensity exercise, when the volume of exercise is held constant. Additional studies support these conclusions (19,97,161,269,313,383).

Is there a threshold intensity of exercise needed to improve cardiorespiratory fitness and to reduce cardiometabolic risk? According to the overload principle of training, exercise below a minimum intensity, or *threshold*, will not challenge the body sufficiently to result in increased $\dot{V}O_{2max}$ and improvements in other physiological parameters (12,14). Evidence for a *minimum* threshold of intensity for benefit is supported in many studies, but not all, and the lack of consistent findings seems to be related to the initial state of fitness and/or conditioning of the subjects (12,345). Swain and Franklin (345) reviewed 18 clinical trials that measured $\dot{V}O_{2max}$ before and after exercise training in 37 training groups and found that subjects with mean baseline $\dot{V}O_{2max}$ values of 40–51 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$ (~11–14 METs) seemed to require an intensity of at least 45% oxygen uptake reserve ($\dot{V}O_2R$) to increase $\dot{V}O_{2max}$, but no apparent threshold was found for subjects with mean baseline $\dot{V}O_{2max}$ <40 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$ (<11 METs), although ~30%$\dot{V}O_2R$ was the lowest intensity studied. Supporting these findings, a comprehensive review of exercise training in runners determined that ''near maximal'' (i.e., 95%–100%$\dot{V}O_{2max}$) training intensities were needed to improve $\dot{V}O_{2max}$ in well-trained athletes, while 70%–80%$\dot{V}O_{2max}$ seemed to provide a sufficient stimulus in moderately trained athletes (254). Thus, a threshold of exercise intensity may vary depending on fitness level, and it may be difficult to precisely define an exact threshold to improve cardiorespiratory fitness (40,196,214). Additional randomized controlled trials and meta-analyses are needed to explore the threshold phenomenon in populations of varying fitness levels and exercise training regimens because of the interactive effects of exercise volume, intensity, duration, and frequency and individual variability of response.

There are even fewer data available on the existence of a threshold to favorably modify other cardiometabolic risk factors. Two comprehensive reviews by Durstine et al. (102,103) found little evidence for an intensity threshold for changes in HDL cholesterol, LDL cholesterol, or triglycerides, although most studies did not control for exercise volume, frequency, and/or duration and were conducted at intensities ≥40%$\dot{V}O_{2max}$. Similar methodological limitations pertain to studies evaluating blood pressure, glucose intolerance, and insulin resistance (6,284,361). Several studies suggest that exercise intensity does not influence the magnitude of loss of body weight or fat stores (99,266), but these data are also confounded by variability in exercise volume and other factors. Corroborating evidence is provided by a study of sedentary subjects who walked at a self-selected pace with fixed volume (10,000 steps per day on 3 $d{\cdot}wk^{-1}$) and improved lipoprotein profiles and expression of genes involved in reverse lipid transport, without accompanying changes in body weight and total body fat (56). Further, a study of 16 pairs of same-sex twins with discordant physical activity patterns found that greater volumes of exercise were associated with lower total, visceral, liver, and intramuscular body fat, with the active twin having on average 50% less visceral fat and 25% less subcutaneous abdominal fat compared with the inactive twin (221).

The short-term effects of exercise on mental health, particularly depression, may be a function of exercise intensity, although a specific threshold has not been identified. There are some data to suggest that the greatest benefit is conferred through moderate- to vigorous-intensity activity consistent with the recommendations presented in this Position Stand (i.e., ≥~17.5 $kcal{\cdot}kg^{-1}{\cdot}wk^{-1}$; ~1400 $kcal{\cdot}wk^{-1}$) (101).

Does the pattern of exercise training make a difference? Current recommendations advise that moderate-intensity physical activity may be *accumulated* in bouts of ≥10 min each to attain the daily goal of ≥30 $min{\cdot}d^{-1}$ (14,155,264,370). The data supporting a discontinuous exercise pattern come primarily from randomized clinical trials examining short versus long bouts of physical activity in relation to changes in cardiorespiratory fitness, blood pressure, and studies of active commuting (141,151). A comprehensive review (260) concluded that the evidence comparing the effectiveness of long versus short bouts of exercise for improving body composition, lipoproteins, or mental health is meager and inconclusive. Only one study, in men, examined short (≤15 min) versus long bouts of physical activity in relation to chronic disease outcomes, and the findings suggest it is the volume of energy expended that is important rather than the duration of the exercise (215). Durations of exercise <10 min may result in fitness and health benefits, particularly in sedentary individuals (215); however, the data are sparse and inconclusive.

A different accumulation issue relates to a pattern of physical activity sometimes called a ''weekend warrior'' pattern, where a large total volume of physical activity may be accumulated over fewer days of the week than is recommended. There are few studies evaluating this exercise pattern, but existing evidence supports the possibility of benefit, although the risks are unknown. A study of men indicated that the weekend warrior pattern was associated with lower rates of premature mortality, compared with being sedentary, but only among men *without* cardiovascular risk factors (217). These results suggest the possibility that physical activity might be needed on a regular basis to improve the risk profile of men with risk factors. A randomized study (253) showed that previously untrained middle-aged participants who accumulated endurance training on consecutive weekend days attained similar improvements in cardiorespiratory fitness compared with those who completed similar mode, volume (~1400 kcal·wk^{-1}), and intensity (90% of the ventilatory threshold) of training but in a pattern consistent with current recommendations (30 min·d^{-1} at 5 d·wk^{-1}).

Another pattern of exercise involves varying the exercise intensity within a *single* bout of exercise, termed *interval training*. With interval training, the exercise intensity is varied at fixed intervals during a single exercise bout, which can increase the total volume and/or average exercise intensity performed. A method commonly used in athletes, short-term (≤3 months) interval training has resulted in similar or greater improvements in cardiorespiratory fitness and cardiometabolic biomarkers such as blood lipoproteins, glucose, interleukin-6, and tumor necrosis factor α, and muscle fatty acid transport compared with single-intensity exercise in healthy adults (77,89,142,161,261,351,388) and persons with metabolic, cardiac, or pulmonary disease (28,104,144,313, 383,399). However, a study of healthy untrained men (268) found that interval running exercise was *more* effective than sustained running of similar total duration (~150 min·wk^{-1}) in improving cardiorespiratory fitness and blood glucose concentrations but *less* effective in improving resting HR, body composition, and total cholesterol/HDL ratio. It is clear from these results that additional studies of interval training are needed to more fully elucidate the effects, particularly with respect to varying interval characteristics (e.g., exercise intensity, work interval duration, rest interval duration) and in diverse populations. Nonetheless, these studies show promise for the use of interval training in adults, but the long-term effects and the safety of interval training remain to be evaluated, although no adverse effects have been reported in the literature to date.

A fourth activity pattern that has important implications for health is sedentary behavior, which is an attribute distinct from physical activity (276). Sitting and low levels of energy expenditure are hallmarks of sedentary behavior and encompass activities such as television watching, computer use, and sitting in a car or at a desk (276). Spending long periods of time in sedentary pursuits is associated with elevated risks of CHD mortality (384) and depression (354), increased waist circumference, elevated blood pressure, depressed lipoprotein lipase activity, and worsened chronic disease biomarkers such as blood glucose, insulin, and lipoproteins (158,159,276, 364,390). Sedentariness is detrimental even among in individuals who meet current physical activity recommendations (158,276). When sedentary activities are broken up by short bouts of physical activity or standing, attenuation of these adverse biological effects can occur (157). This evidence suggests it is not enough to consider whether an individual engages in adequate physical activity to attain health benefits but also that health and fitness professionals should be concerned about the amount of time clients spend in activities such as television watching and sitting at a desk.

WHAT IS THE EFFECT OF EXERCISE TRAINING ON CARDIORESPIRATORY FITNESS AND CARDIOVASCULAR AND METABOLIC DISEASE (CARDIOMETABOLIC) RISK FACTORS?

Studies substantiating the previous Position Stand (12), the AHA/ACSM statements (155,264), the *2008 Physical Activity Guidelines for Americans* (370), and *ACSM's Guidelines for Exercise Testing and Prescription* (14) clearly demonstrate that exercise of the intensity, duration, and frequency recommended here results in improvements in cardiorespiratory fitness (i.e., $\dot{V}O_{2max}$). Moreover, a plateau in the training effect occurs, whereby additional increases in exercise volume result in little or no additional improvements in $\dot{V}O_{2max}$ (12).

Cardiorespiratory exercise reduces several cardiometabolic disease risk factors, although the magnitude of effect is modest, varies according to individual and exercise program characteristics, and a change in one cardiometabolic risk factor apparently occurs independently of a change in another (271,361,395). Favorable improvements in hypertension, glucose intolerance, insulin resistance, dyslipidemia, and inflammatory markers have been reported in middle-aged and older persons exercising within the volumes and quality of exercise recommended here, even during weight regain (47,102,103,184,260,284,288,310,328,357,358,361, 376,385). The benefits of exercise on cardiometabolic risk factors are acute (lasting hours to days) and chronic, highlighting the value of regular exercise participation on most days of the week (360,388,389). Exercise without dietary modification has a modest effect (~2%–6%) on short-term (≤6 months) weight loss (99), but favorable changes in associated cardiometabolic risk factors (e.g., visceral abdominal fat, total body fat, and biomarkers) can occur even in the absence of concomitant weight reduction (96,150,195, 288,361), albeit weight loss enhances these improvements (102,103,256,361). Some risk factor changes, such as reduction of LDL and the attenuation of decline in HDL accompanying reduced dietary intake of saturated fat, occur *only* when exercise is combined with weight loss (102,103,361).

What is the effect of varying exercise volumes on the health and fitness of adults? Although epidemiological evidence demonstrates a dose–response *association* between the volume of exercise and health outcomes, randomized clinical trials (RCT) are needed to demonstrate *causal* biological effects. Until recently, few data from RCT were available comparing the effects of different fixed exercise volumes on fitness and biomarkers of disease. Church et al. (76) evaluated the effect of varying exercise volumes at a fixed intensity (50%$\dot{V}O_{2max}$) in sedentary, overweight, or obese postmenopausal women randomized to exercise volumes of 50%, 100%, or 150% of the recommended weekly energy expenditure (4, 8, and 12 $kcal{\cdot}kg^{-1}{\cdot}wk^{-1}$, respectively; or approximately 330, 840, and 1000 $kcal{\cdot}wk^{-1}$, respectively). A dose–response effect across the three volumes was observed, and modest improvements in cardiorespiratory fitness (4%–8%) occurred at 6 months at exercise training volumes as low as one-half of the recommended weekly volume. A preliminary report suggests that initial level of fitness may affect the training responses to a set volume of exercise (18), but more definitive evidence is needed before the results of these studies can be generalized to persons of higher fitness levels.

HOW ARE EXERCISE INTENSITY AND VOLUME ESTIMATED?

Most epidemiologic and many laboratory studies providing evidence of the beneficial effects of exercise have classified intensity according to the *absolute* energy demands of the physical activity (323). Measured or estimated measures of absolute exercise intensity include caloric expenditure ($kcal{\cdot}min^{-1}$), absolute oxygen uptake ($mL{\cdot}min^{-1}$ or $L{\cdot}min^{-1}$), and METs. These absolute measures can result in misclassification of exercise intensity (e.g., moderate, vigorous) because they do not consider individual factors such as body weight, sex, and fitness level (4,58,173). Measurement—and consequently misclassification—error is greater when using estimated rather than directly measured absolute energy expenditure, and under free-living compared with laboratory conditions (4,58,173). For example, an older person working at 6 METs may be exercising at a vigorous to maximal intensity, while a younger person working at the same absolute intensity will be exercising moderately (173). Therefore, for individual exercise prescription, a *relative* measure of intensity (i.e., the energy cost of the activity relative to the individual's maximal capacity) is more appropriate, especially for older and deconditioned persons (173,264).

There are several commonly used methods of estimating relative exercise intensity during cardiorespiratory exercise: $\dot{V}O_2R$, HRR, percent of the maximum HR (%HR_{max}), %$\dot{V}O_{2max}$, and %MET_{max}. Each of these methods for prescribing exercise intensity has been shown to result in improvements in cardiorespiratory fitness when used for exercise prescription, thence can be recommended when prescribing exercise for an individual (12).

Table 5 shows the approximate classification of exercise intensity using relative and absolute methods commonly used in practice. No studies have compared all of the methods of measurement of exercise intensity simultaneously; therefore, it cannot be assumed that one method of determining exercise intensity is necessarily equivalent to that derived using another method. It is prudent to keep in

TABLE 5. Classification of exercise intensity: relative and absolute exercise intensity for cardiorespiratory endurance and resistance exercise.

	Cardiorespiratory Endurance Exercise											Resistance Exercise
	Relative Intensity				Intensity (%$\dot{V}O_{2max}$) Relative to Maximal Exercise Capacity in METs			Absolute Intensity	Absolute Intensity (MET) by Age			Relative Intensity
Intensity	%HRR or %$\dot{V}O_2R$	%HR_{max}	%$\dot{V}O_{2max}$	Perceived Exertion (Rating on 6–20 RPE Scale)	20 METs %$\dot{V}O_{2max}$	10 METs %$\dot{V}O_{2max}$	5 METs %$\dot{V}O_{2max}$	METs	Young (20–39 yr)	Middle-aged (40–64 yr)	Older (≥65 yr)	% 1RM
Very light	<30	<57	<37	<Very light (RPE < 9)	<34	<37	<44	<2	<2.4	<2.0	<1.6	<30
Light	30–39	57–63	37–45	Very light–fairly light (RPE 9–11)	34–42	37–45	44–51	2.0–2.9	2.4–4.7	2.0–3.9	1.6–3.1	30–49
Moderate	40–59	64–76	46–63	Fairly light to somewhat hard (RPE 12–13)	43–61	46–63	52–67	3.0 to 5.9	4.8–7.1	4.0–5.9	3.2–4.7	50–69
Vigorous	60–89	77–95	64–90	Somewhat hard to very hard (RPE 14–17)	62–90	64–90	68–91	6.0–8.7	7.2–10.1	6.0–8.4	4.8–6.7	70–84
Near-maximal to maximal	≥90	≥96	≥91	≥Very hard (RPE ≥ 18)	≥91	≥91	≥92	≥8.8	≥10.2	≥8.5	≥6.8	≥85

Table adapted from the American College of Sports Medicine (14), Howley (173), Swain and Franklin (344), Swain and Leutholtz (346), Swain et al. (347), and the US Department of Health and Human Services (370).
HR_{max}, maximal HR; %HR_{max}, percent of maximal HR; HRR, HR reserve; $\dot{V}O_{2max}$, maximal oxygen uptake; %$\dot{V}O_{2max}$, percent of maximal oxygen uptake; $\dot{V}O_2R$, oxygen uptake reserve; RPE, ratings of perceived exertion (48).

mind that the relationships among actual energy expenditure, HRR, $\dot{V}O_2R$, $\%HR_{max}$, and $\%\dot{V}O_{2max}$ can vary considerably depending on exercise test protocol, exercise mode, exercise intensity, resting HR, fitness level, age, body composition, and other factors (57,90,185,277,289,315,336). The HRR or $\dot{V}O_2R$ methods may be preferable for exercise prescription because exercise intensity can be underestimated or overestimated when using $\%HR_{max}$ and $\%\dot{V}O_{2max}$ methods (52,57,231,287,342,346). However, the advantage of the HRR or $\dot{V}O_2R$ methods has not been supported by all studies (90,277). The accuracy of the $\%HR_{max}$ and HRR methods may be influenced by the method used to estimate maximal HR. Specialized regression equations for estimating maximal HR (133,147,352,407) are purported to be superior to the commonly used equation of 220 − age for the estimation of maximal HR because influences associated with aging and possible gender differences (133,147,156,352). Although these equations are promising, further study in diverse populations composed of men and women is needed before one or more can be recommended for universal application. Direct measurements of HR and oxygen uptake are recommended for individualized exercise prescription for greater accuracy, but when not feasible, estimation of exercise intensity is acceptable.

MET-minutes per week and kilocalories per minute per week have been used for estimating exercise volume in research, but these quantifications are seldom used for exercise prescription for individuals. Yet, these may be useful in approximating the gross energy expenditure of an individual because of the proliferating evidence supporting the important role of exercise volume in realizing health and fitness outcomes. The METs per minute and kilocalories per week for a wide array of physical activities can be estimated using previously published tables (4,5).

CAN STEPS PER DAY BE USED TO PRESCRIBE EXERCISE?

Pedometers are popular and effective for promoting physical activity (366) and modest weight loss (308), but they provide an inexact index of exercise volume (26,368). They are limited in that the ''quality'' (e.g., speed, grade, duration) of steps often cannot be determined. A goal of 10,000 steps per day is often cited, but even fewer steps may meet contemporary exercise recommendations (367). For example, recent data from ''America on the Move'' (27) showed those individuals who reported ''exercising strenuously'' on 3 $d \cdot wk^{-1}$ (duration of exercise not ascertained), a level that probably meets current recommendations, accumulated a mean of 5486 ± 231 SEM steps per day. People reporting 4 $d \cdot wk^{-1}$ of ''strenuous exercise'' accumulated 6200 ± 220 steps per day, and 7891 ± 540 steps per day were reported by those ''exercising strenuously'' on 6–7 $d \cdot wk^{-1}$. In a randomized trial evaluating different doses of physical activity on fitness levels, initially sedentary women who engaged in a new program of physical activity meeting current exercise recommendations averaged about 7000 steps per day (187). Two meta-analyses of pedometer use showed that participants in randomized clinical trials *increased* their daily steps on average by about 2000 steps per day, equal to walking approximately 1 $mile \cdot d^{-1}$, and few of the most sedentary subjects achieved the goal of 10,000 steps per day (51,193). In participants with elevated blood pressure, an increase of 2000 steps per day was associated with a modest decrease in systolic blood pressure (~4 mm Hg), independent of changes in body mass index, suggesting that fewer than 10,000 steps per day may provide health benefits. Recent work to determine step count cut points corresponding to moderate-intensity walking demonstrated that 100 steps per minute is a very rough approximation of moderate-intensity exercise (242). Because of the substantial errors of prediction using either step counts or this algorithm to estimate energy expenditure (204,242,368), it may be prudent to use both steps per minute *combined with* currently recommended durations of exercise for exercise prescription (e.g., 100 steps per minute for 30 min per session) (242,368).

WHAT ARE THE BENEFITS OF IMPROVING MUSCULAR FITNESS?

The health benefits of enhancing muscular fitness have become well established during the past decade (392). Higher levels of muscular strength are associated with significantly better cardiometabolic risk factor profiles (188,189), lower risk of all-cause mortality (117,128,265), fewer CVD events (128,353), lower risk of developing functional limitations (54,235), and nonfatal disease (189). At present, there are insufficient prospective data on the dose–response characteristics between muscular fitness and health outcomes or the existence of a threshold for benefit to recommend a minimal level of health-related muscular strength, power, or endurance (31). Apart from greater strength, there is an impressive array of changes in health-related biomarkers that can be derived from regular participation in resistance training, including improvements in body composition (177,178,328), blood glucose levels (66,67,207,327,328), insulin sensitivity (55,199), and blood pressure in persons with prehypertension or stage 1 hypertension (80,328). Accordingly, resistance training may prove to be effective to prevent and treat the ''metabolic syndrome'' (234).

Importantly, exercise that promotes muscle strength and mass also effectively increases bone mass (bone mineral density and content) and bone strength of the specific bones stressed (201,233,341) and may serve as a valuable measure to prevent, slow—or even reverse—the loss of bone mass in people with osteoporosis (201,233,341). Because muscle weakness has been identified as a risk factor for the development of osteoarthritis, resistance training may reduce the chance of developing musculoskeletal disorder (331). In persons with osteoarthritis, resistance training can reduce pain and disability (39,252).

The mental health benefits associated with resistance training have received less attention than cardiorespiratory exercise. Preliminary work suggests that resistance training may prevent and improve depression and anxiety (65,271,282), increase ''energy'' levels, and decrease fatigue (294). However, these results are inconclusive and require further study.

HOW CAN EXERCISE IMPROVE AND MAINTAIN MUSCULAR FITNESS?

Muscular fitness is composed of the functional parameters of strength, endurance, and power, and each improves consequent to an appropriately designed resistance training regimen. As the trained muscles strengthen and enlarge (hypertrophy), the resistance must be progressively increased if additional gains are to be accrued. To optimize the efficacy of resistance training, the program variables (frequency, intensity, volume, rest intervals) are best tailored to the individual's goals (13).

The focus here is on program design for adults seeking *general or overall* muscular fitness with associated health benefits. Individuals who desire to engage in more advanced or extensive resistance training regimens aimed at achieving maximal muscular strength and hypertrophy are referred to the relevant ACSM Position Stand (13).

What types of exercises improve muscular fitness? Many types of resistance training equipment can effectively be used to improve muscular fitness, including free weights, machines with stacked weights or pneumatic resistance, and even resistance bands. A resistance training program emphasizing dynamic exercises involving concentric (shortening) and eccentric (lengthening) muscle actions that recruit multiple muscle groups (multijoint exercises) is recommended, including exercises targeting the major muscle groups of the chest, shoulders, back, hips, legs, trunk, and arms (13). Single-joint exercises that isolate functionally important muscle groups such as the abdominals, lumbar extensors (lower back), calf muscles, hamstrings, quadriceps, biceps, etc., should also be included. To prevent muscular imbalances, training opposing muscle groups (antagonists), such as the quadriceps and hamstrings, as well as the abdominals and lumbar extensors, is important.

The exercises should be executed using correct form and technique, including performing the repetitions deliberately and in a controlled manner, moving through the full range of motion of the joint, and using proper breathing techniques (i.e., exhalation during the concentric phase and inhalation during the eccentric phase; avoiding the Valsalva maneuver) (13). Training that exclusively features eccentric contractions should be discouraged because severe muscle damage and soreness as well as serious complications such as rhabdomyolisis can ensue (78).

How many sets of exercises are needed? Most individuals respond favorably (e.g., hypertrophy and strength gains) to two to four sets of resistance exercises per muscle group (13,386), but even a single set of exercise may significantly improve muscle strength and size, particularly in novice exercisers (12,13). The target number of sets per muscle group can be achieved with a single exercise or by using a combination of more than one exercise movement (e.g., two sets of shoulder press and two sets of lateral raises).

What duration of rest intervals between sets and intensity is appropriate to improve muscular fitness? For a general fitness program, rest intervals of 2–3 min are most effective for achieving the desired increases in muscle strength and hypertrophy (13). Robust gains in both hypertrophy and strength result from using a resistance equivalent to 60%–80% of the individual's one-repetition maximal (1RM) effort (386). For novice through intermediate strength trainers, a load of 60%–70% of the 1RM is recommended (i.e., moderate to hard intensity), while experienced exercisers may work at ≥80% of the 1RM (i.e., hard to very hard intensity) (13). The selected resistance should permit the completion of 8–12 repetitions per set—or the number needed to induce muscle fatigue but not exhaustion. For people who wish to focus on improving muscular endurance, a lower intensity (i.e., <50% of 1RM; light to moderate intensity) can be used to complete 15–25 repetitions per set, with the number of sets not to exceed two (59). Table 5 shows the relative intensities for resistance training.

How often should resistance training be performed? Meta-analyses show that optimal gains in muscle function and size can occur with training two to three times per week (285,306,386). This can be effectively achieved with ''whole body'' training sessions completed two to three times a week or by using a ''split-body'' routine where selected muscle groups are trained during one session and the remaining muscle groups in the next. A rest period of 48 to 72 h between sessions is needed to optimally promote the cellular/molecular adaptations that stimulate muscle hypertrophy and the associated gains in strength (36).

Are there differences in resistance training recommendations according to individual characteristics? The resistance training recommendations described here are appropriate for men and women of virtually all ages (1,386). Older, very deconditioned, or frail individuals initiating a resistance training regimen, may begin with lower resistance, perhaps 40%–50% of 1RM (i.e., very light to light intensity), along with a greater number of repetitions (i.e., 10–20) (110). After achieving an acceptable level of muscular conditioning, older and frail persons can increase the resistance and perform the exercises as detailed above (110). Because some studies indicate that the risk of accidental falls and resultant bone fractures is more closely related to a decline in muscular power than strength, it has been suggested that resistance training for the older person should emphasize the development of power (46,71). Research has shown that completing three sets of 8–12 repetitions at a very light to moderate intensity (20%–50% of 1RM) effectively increases strength and power and improves balance in older persons (93,274). Although encouraging, additional studies are needed to provide definitive guidelines regarding exercise prescription for power training in older individuals.

HOW CAN MEASURES OF PERCEIVED EXERCISE INTENSITY AND AFFECTIVE VALENCE BE USED?

Instruments that measure perceived effort and the pleasantness of exercise (i.e., affective valence), including the Borg RPE scales (48,267), the OMNI scales (311,312,373), the Talk Test (283), and the Feeling Scale (152) can be used to modulate or refine the prescribed exercise intensity of both cardiorespiratory and resistance exercise, with the most data available on the cardiorespiratory exercise. However, the evidence is insufficient to support using these methods as a *primary* method of exercise prescription. The RPE scales (48,267) and the modality-specific (i.e., walking, cycling,) OMNI scales (311,312,373) have been used most extensively and demonstrate moderate to strong validity compared with other measures of cardiorespiratory exercise intensity (i.e., %$\dot{V}O_{2max}$, %HR_{max}, blood lactate concentrations) (72,179), although the strength of these relationships may differ depending on the characteristics of the exercise (72). The OMNI resistance exercise scale has reasonable concurrent validity compared with the RPE scale (208,311). The Talk Test (283) is moderately associated with cardiorespiratory exercise intensity (e.g., ventilatory threshold, HR, oxygen uptake, and blood lactate) in some (53,121,283) but not all studies (316). Measures of the pleasantness/unpleasantness of exercise (i.e., affective valence) hold promise as a means to regulate and monitor exercise intensity because they can accurately identify the transition across the lactate threshold during cardiorespiratory exercise (106,108). The Feeling Scale (152), one measure of affective valence, seems to be an effective way for an individual to self-regulate exercise intensity, particularly during walking exercise (314).

WHAT ARE THE BENEFITS OF FLEXIBILITY EXERCISE?

Although joint flexibility decreases with aging, flexibility can be improved across all age groups (12,15,95,127,264). Joint range of motion is improved transiently after flexibility exercise, chronically after approximately 3–4 wk of regular stretching at a frequency of at least two to three times a week (94,95,146,202,295,300), and it may improve in as few as 10 sessions with an intensive program (145). Flexibility exercises may enhance postural stability and balance (83), particularly when combined with resistance exercise (38). No consistent link has been shown between regular flexibility exercise and a reduction of musculotendinous injuries, prevention of low back pain, or DOMS (9,116,163,248,355,401).

How can exercise be used to improve and maintain muscular fitness? The goal of a flexibility program is to develop range of motion in the major muscle–tendon groups in accordance with individualized goals. Certain performance standards discussed below enhance the effectiveness of flexibility exercises.

What types of exercise can improve flexibility? Several types of flexibility exercises can improve range of movement. Ballistic methods or ''bouncing'' stretches use the momentum of the moving body segment to produce the stretch (402). Dynamic or slow movement stretching involves a gradual transition from one body position to another, and a progressive increase in reach and range of motion as the movement is repeated several times (249). Static stretching involves slowly stretching a muscle/tendon group and holding the position for a period (i.e., 10–30 s). Static stretching can be active or passive (397). Active static stretching involves holding the stretched position using the strength of the agonist muscle, as is common in many forms of yoga. In passive static stretching, a position is assumed while holding a limb or other part of the body with or without the assistance of a partner or device (such as elastic bands or a barre). Proprioceptive neuromuscular facilitation (PNF) methods take several forms but typically involve an isometric contraction of the selected muscle–tendon group followed by a static stretching of the same group (i.e., contract–relax) (299,322).

Do similar benefits result from the various types of flexibility exercise? Ballistic stretching, when properly performed, increases flexibility similarly to static stretching, and may be considered for individuals engaging in activities that involve ballistic movements, such as basketball (85,209,232,400,402). PNF and static stretching elicit greater gains in joint range of motion than dynamic or slow movement stretching (22,95,202,270). PNF may produce slightly larger gains in flexibility of some joints compared with other techniques, but it is less practical because of the need for a partner (322). However, one comparative review reported that range of motion improvements of 5°–20° occurred after 3–10 wk of hamstring stretching irrespective of whether static or PNF techniques were performed (95).

How long should a stretch be held? Holding a stretch for 10–30 s at the point of tightness or slight discomfort enhances joint range of motion, with little apparent benefit resulting from longer durations (21,95). Older persons may realize greater improvements in range of motion with longer durations (30–60 s) of stretching (115). A 20%–75% maximum contraction held for 3–6 s followed by a 10- to 30-s assisted stretch is recommended for PNF techniques (45,114,322).

How many repetitions of stretching exercises are needed? Repeating each flexibility exercise two to four times is effective, with enhancement of joint range of motion occurring during 3–12 wk (21,95,264). The goal is to attain 60 s of total stretching time per flexibility exercise by adjusting duration and repetitions according to individual needs. For example, 60 s of stretch time can be met by two 30-s stretches or four 15-s stretches (95).

How often should stretching exercise be performed? Performing flexibility exercises ≥2–3 d·wk^{-1} is effective (95,203), but greater gains in joint range of motion are accrued with daily flexibility exercise (115, 145,146,293,299,394).

What types of flexibility exercises should be performed? A series of exercises targeting the major muscle–tendon units of the shoulder girdle, chest, neck, trunk, lower back, hips, posterior and anterior legs, and ankles are recommended. For most individuals, this routine can be completed within 10 min.

When should stretching be performed? Flexibility exercise is most effective when the muscle temperature is elevated through light-to-moderate cardiorespiratory or muscular endurance exercise or passively through external methods such as moist heat packs or hot baths, although this benefit may vary across muscle–tendon units (29,249,326).

Stretching exercises can have a negative effect on subsequent muscle strength and power and sports performances, particularly when strength and power are important (248,396). However, limited evidence is available about the effects of stretching programs of different durations and types (e.g., passive vs dynamic) on exercise activities with varying characteristics, particularly in individuals who are exercising for improving fitness. Further research is needed before making universal recommendations concerning the timing of stretching in association with other exercise activities. Nonetheless, based on the available evidence, whenever possible, persons engaging in a general fitness program should perform flexibility exercise after cardiorespiratory or resistance exercise—or alternatively—as a stand-alone program. For most persons, a dynamic, cardiorespiratory endurance exercise warm-up is superior to flexibility exercise for enhancing cardiorespiratory or resistance exercise (especially with high duration and repetitions) performance (29,124, 248,249,326). A pre-event warm-up that includes both cardiorespiratory and flexibility exercise has benefits for specific recreational sports such as dancing (143).

WHAT ARE THE BENEFITS OF NEUROMOTOR EXERCISE TRAINING?

Neuromotor exercise training, sometimes called functional fitness training, incorporates motor skills such as balance, coordination, gait, and agility, and proprioceptive training. Multifaceted physical activities such as tai ji (tai chi), qigong, and yoga involve varying combinations of neuromotor exercise, resistance exercise, and flexibility exercise. Neuromotor exercise training is beneficial as part of a comprehensive exercise program for older persons, especially to improve balance, agility, muscle strength, and reduce the risk of falls (38,181,194,224,264,350,369). Tai ji, the most widely studied neuromotor activity, and exercises incorporating balance and agility can be effective in improving balance, agility, motor control, proprioception, and quality of life (69,74,131, 132,181,205,222,223,230,363,375,378). Agility and balance training may reduce the risk of falling and fear of falling (194,226,227) and probably reduce the number of falls, although more definitive evidence is needed to confirm this finding (153,227,228,230,236,264,404).

Few studies have evaluated the benefits of neuromotor exercise training in younger adults. The only English-language study of tai ji in middle-aged adults reported improvements in balance (363). Limited evidence suggests that exercises involving balance and agility may reduce anterior cruciate injury (165,350) and reduce recurrent ankle injury in men and women athletes (174). Definitive recommendations as to whether neuromotor exercise is beneficial in young and middle-aged adults cannot be made owing to a paucity of data, although there *may* be benefit, especially if participating in physical activities requiring agility, balance, and other motor skills. More data are needed in all age groups to elucidate the specific health-related changes resulting from such training and to determine the effectiveness of various exercise types and doses (i.e., frequency, duration, and intensity) and training programs.

What quality and quantity of neuromotor exercise are needed? The frequency and duration of neuromotor exercise training to accrue health and fitness benefits are uncertain because there is variability in the quality of available studies, the types, duration, and frequency of neuromotor exercise used; there is inconsistent length of the training programs, and no standardized outcome measures have been used (138,264,404). Further confounding the interpretation of the results, many studies have combined resistance, cardiorespiratory, and/or flexibility training with neuromotor exercise (138,404). Development of some degree of proficiency in activities, such as balance training and tai ji, may also be important with respect to achieving improvements in physical function and in outcomes such as falls (404). Studies that have resulted in improvements have mostly used training frequencies of ≥2–3 d·wk^{-1} with exercise sessions of ≥20–30 min in duration, for a total of ≥60 min of neuromotor exercise per week; however, more research is needed before any definitive recommendations can be made. There is no available evidence concerning the number of repetitions of exercises needed, the intensity of the exercise, or optimal methods for progression.

HOW DOES THE EXERCISE TRAINING RESPONSE VARY BETWEEN INDIVIDUALS?

The magnitude of effect of a particular training regimen can vary significantly among individuals, and there are some exercisers who may not respond as expected (49,330). Multiple factors are associated with variation in training effects across individuals, including the characteristics of the training regimen, environmental conditions, and numerous individual factors, such as habitual physical activity, fitness level, physiological and genetic variability, and social and psychological factors (12,33,197,239,298). Age and sex seemingly have little influence on the variability of response to exercise training (49,134,393), but this is not universally reported (104,220).

HOW MUCH EXERCISE IS NEEDED TO MAINTAIN THE BENEFICIAL EFFECTS OF EXERCISE TRAINING?

When physical conditioning is stopped or reduced, training-induced cardiorespiratory, metabolic, musculoskeletal, and neuromotor adaptations are reversed to varying degrees over time (63,135,349,358,379,380,381). The level of fitness, age, length of time in training, habitual physical activity, the muscle groups involved, and genetic factors add to this variability (49,154,393).

Because individuals may not always be able to adhere to their exercise regimens, an important question remains, ''Once enhanced fitness has been achieved, does an individual have to train at the same exercise volume to maintain these adaptations?'' It seems that if an occasional exercise session is missed, or if the training volume becomes reduced, $\dot{V}O_{2max}$ will not be adversely affected. A series of studies in trained athletes (88,166–168,240,309) found that decreasing the volume, frequency, and/or or intensity of exercise training had little or only modest influence on $\dot{V}O_{2max}$ over periods of several months. Even so, many physiological changes occur as soon as 1–2 wk after cessation of exercise training, whereas continuing to exercise at reduced volume may attenuate these changes (44,191, 332,377). Unfavorable alterations in HR variability, endothelial function, blood lipoproteins, glucose tolerance, insulin sensitivity, body composition, and inflammatory markers such as interleukin 6 have been reported after cessation of exercise training (332,358,377,379,380,381,393). A study of more than 6000 runners followed for 7.4 yr (393) determined that the magnitude of increase in abdominal adiposity associated with a reduction in training depended on the magnitude of the reduction in training volume in a dose-dependent manner. Although these results cannot be completely generalized for everyone, they do suggest that more exercise is required to *improve* cardiorespiratory fitness and cardiometabolic health than is required to *maintain* these improvements.

Resistance training–induced improvements in muscle strength and power reverse quickly with complete cessation of exercise, although neuromuscular and functional changes seem to be maintained for a longer period (63,112,113,162, 191). Muscular strength, functional performance, and metabolic health indicators may be maintained by as little as a single session per week of moderate- to hard-intensity exercise (112,113,365,393). Intensity seems to be an important component of maintaining the effects of resistance training (112).

Improvements in joint range of motion reverse within 4–8 wk on cessation of stretching exercise, although there are variable responses among muscle–tendon groups (115,145,146,200,394). There is a paucity of data on the effects of reducing the frequency or duration of stretching exercise, although a recent report showed that individuals who reduced participation in stretching exercise from daily to 2–3 $d \cdot wk^{-1}$ maintained joint range of motion (297). Data on the reversibility of the effects of neuromotor exercise are likewise limited.

Another important question relevant to the maintenance of the training effect is, ''Can training effects be attained by training other limbs?'' After endurance training of one limb or a set of limbs, most of the improvements in cardiorespiratory fitness occur in the trained limbs, with small improvements elicited in untrained limbs (i.e., specificity of training) (34,290,348). Arm training has little effect on the deterioration in metabolic response to leg exercise, which occurs with cessation of leg training (34,279,290). However, a cross-education or cross-training effect can occur in an untrained ipsilateral (opposite) limb after resistance training of the opposite limb and in the arms with leg training (and vice versa) (3,174,175,219,258,259). The cross-education effect results from adaptations in neuromotor control rather than skeletal muscle adaptations (62,218). A meta-analysis by Munn et al. (258) reported modest improvements in strength (~8%) in the untrained contralateral limb, a level that was approximately 25% of the strength improvement in the trained limb (62). The cross-education effects of training one limb are seemingly greater when the dominant limb is trained (and the effects transferred to the nondominant limb) rather than vice versa (111). There are no available data on the health benefits of contralateral exercise training.

HOW CAN BEHAVIOR BE IMPROVED TO ENHANCE EXERCISE ADOPTION AND ADHERENCE?

Despite the benefits of exercise, a large proportion of adults fail to achieve the recommended levels of physical activity (69,148,149). Exemplifying the problem, walking is the most popular physical activity identified by adults (329), but fewer than 7% of those whose primary exercise is walking are doing so with the frequency, duration, and intensity to meet contemporary physical activity recommendations (296). Numerous nonmodifiable sociodemographic and neighborhood environmental characteristics are associated with exercise behavior (307), but in this Position Stand, the focus is on *modifiable* factors associated with individual exercise behavior. The role of individual choice, preference, and enjoyment is emphasized in the exercise prescription, particularly because individuals can achieve current recommendations in many ways (391).

How do exercise intensity, mode, duration, and frequency influence exercise behavior? Public health efforts promoting moderate-intensity exercise after the release of the CDC/ACSM statement (280), and US Surgeon General's report (371) were initiated because of the belief that the promotion of moderate-intensity exercise would lead to greater adoption and adherence to exercise (273), but widespread adoption of moderate-intensity activity in the population has not yet occurred (70). A meta-analysis by Rhodes et al. (307) reported that factors related to the exercise prescription, including duration, frequency, intensity, and volume, have little or very small effects on exercise adherence. However, there is other evidence suggesting that individuals are somewhat more likely to adhere to moderate-intensity compared with vigorous-intensity exercise (91,190, 197,307,314). This effect may be moderated by previous exercise behavior so that individuals with previous exercise experience may respond more favorably to vigorous exercise, whereas habitually inactive people adopting exercise may be better suited to—and self-select—moderate-intensity exercise (17,35,107,319). Nonetheless, it is *reasonable* to prescribe moderate-intensity activity to enhance adoption and adherence, particularly in novice exercisers.

How do exercise mode and program format affect exercise behavior? Mode of exercise (i.e., aerobic vs resistance exercise, walking vs running) has no or very minimal effect on adherence to exercise (307). Supervision by an experienced exercise leader can, on the other hand, enhance adherence (87,319). Structured, supervised programs and unsupervised, home-based programs can increase exercise behavior, and there seems to be no differences in adherence to home-based and traditional exercise programs (86,100,307), although some studies have found an advantage for home-based exercise (91,131,183). Community-based interventions and those incorporating program components such as brief advice, the use of pedometers, telecommunications, and group support effectively increase walking duration by 30–60 min in previously inactive persons (51,272). Unfortunately, few data exist on the long-term effects of such interventions (30). Even if the long-term adherence between structured, supervised programs and home-based exercise programs is similar, cost-effectiveness analyses support the promotion of home-based programs (317,321).

There have been few systematic studies about who adopts and maintains resistance training programs (73,84,91, 246,319) or flexibility or neuromotor exercise (119), so it is difficult to make specific recommendations about how to enhance adoption and maintenance of these modes of exercise. Limited evidence suggests that enhancing desires for strength and feelings of empowerment, previous exercise experience, and supervision by an experienced instructor may increase adoption and adherence of resistance training among older adults (304,319).

How do affective responses to exercise influence exercise behavior? Individuals are often advised to select an activity they enjoy for exercise because of an inherent belief that persons are more likely to adopt and maintain a behavior they enjoy (382). Limited evidence suggests that pleasant affective responses to exercise (i.e., how enjoyable or pleasant is the exercise) may enhance future exercise behavior and vice versa (50,198,206, 239,391). More negative affect is reported when exercising above the ventilatory threshold (17,108,278). Thus, prescribing exercise at an intensity below the ventilatory threshold may enhance affective responses to exercise (225) and improve exercise adherence and/or maintenance. Exercise environments with engaging distractions (e.g., music, an instructor, television, scenery) may also ameliorate affective experiences (and adherence), but additional confirmation is needed (16,245).

What types of individual interventions are effective in improving exercise adoption and maintenance and reducing sedentary behavior? Although trials of physical activity counseling by physicians have demonstrated equivocal effectiveness, leading the US Preventive Services Task Force to conclude, "the evidence is insufficient to recommend for or against behavioral counseling in primary care settings to promote physical activity" (105). Other medical and voluntary health associations have adopted the position that health providers should make physical activity counseling a part of routine patient visits because of the extensive benefits of physical activity (180). However, there is evidence that brief counseling by health care professionals can increase exercise adoption when it incorporates established counseling strategies and techniques from individual behavioral programs described below (2,140,180,286,403).

Several scientific reviews have shown that individualized, tailored behavioral programs can enhance the adoption and short-term adherence to exercise (169,190,239). Exercise programs conducted in diverse populations in a variety of settings have been effective in promoting short-term increases in physical activity when they are based on health behavior theoretical constructs (23), are individually tailored (239), and use behavioral strategies such as goal setting, social support, reinforcement, problem solving, and relapse prevention (190). Individually tailored interventions delivered using various modalities including print (43), telephone, Internet/computer (374), and group counseling (303) can be effective in enhancing exercise adoption but are at best marginally effective for increasing exercise maintenance. Despite the well-documented problems with long-term adherence and exercise dropout (98), few data exist regarding the factors associated with maintaining exercise behavior (238,257). Successful interventions to improve exercise maintenance have incorporated continued contact and social support (68) and access to home exercise equipment (182). Dual interventions in children and adolescents targeting sedentary behavior *and* physical activity have been effective in reducing sedentary behavior and increasing physical activity (109). There is a dearth of interventions targeting sedentary behavior in adults, but the work in children supports the possibility of successfully intervening in adults. Further research on exercise maintenance and the development of behavioral theory is needed to understand not only how to assist individuals in initiating exercise, reducing sedentary behavior, but also how people can *maintain* that activity over their lifetime (238,276,321).

WHAT ARE RISKS ASSOCIATED WITH EXERCISE AND HOW CAN THEY BE REDUCED?

Although regular exercise helps to protect against and treat aging-related chronic diseases, the risk of CHD and musculoskeletal complications increase transiently during strenuous physical activity compared with the risk at other times (362). Musculoskeletal injury is the most common exercise-related complication (7,8,171,172,192). Overweight and obese adults have engaged in greater volumes of exercise than those recommended here without adverse sequelae, suggesting that this level of activity can be sustained safely (99,129).

The type and intensity of the exercise seem to be more important factors in the incidence of injury, with the volume of exercise performed apparently of lesser importance (7,8,171,172,186,393). Walking and moderate-intensity physical activities are associated with a very low risk of musculoskeletal complications (61,82,171,291), whereas jogging, running, and competitive sports are associated with increased risk of injury (79,116,172,243). Sports-related mortality among adult athletes reflects the popular sporting events engaged in by a population (170,334). For example, in countries where soccer is popular, deaths during that sport are more common. Unaccustomed exercise demands, especially during the initial weeks of a physical conditioning regimen, often result in muscle soreness, musculoskeletal injury, and attrition (12). Rhabdomyolisis associated with exercise is an uncommon, but serious, disorder resulting from damage to the skeletal muscle that can cause acute kidney failure, cardiac arrhythmias, and even death (78). The risk of rhabdomyolisis is increased in both experienced and novice exercisers who undertake *unaccustomed* eccentric exercise, particularly under hot ambient conditions (78).

Commonly used methods to reduce musculoskeletal injury and complications, such as the warm-up and cool-down, stretching, and gradual progression of volume and intensity, seem to be helpful at least under some circumstances, but controlled studies substantiating the effectiveness of these methods are insufficient (9,123,124,164,248,355).

Acute myocardial infarction and sudden cardiac death can be triggered by *unaccustomed vigorous* physical exertion, particularly in sedentary men and women with subclinical or known CHD, and when concomitant chronic diseases and medical conditions and/or superimposed environmental stressors are involved (362). However, this risk decreases with increasing volumes of *regular* exercise (362). Running, racquet sports, and strenuous sports activity seem to be associated with a greater incidence of CVD events than other activities (362).

Population studies have shown that forewarning signs or symptoms often precede exercise-related CHD events, but individuals and their health care providers may ignore or inadequately evaluate these, especially in habitually active persons (362). Careful evaluation of exercisers for warning signs and symptoms, and informing both novice and regular exercisers about common signs and symptoms of CHD disease and how to respond to them may reduce the risk of untoward CHD events (362).

Using a well-designed health assessment or medical history questionnaire (e.g., Physical Activity Readiness Questionnaire (PAR-Q)) to identify conditions, signs, symptoms, and risk factors that are associated with an increased risk of CVD events during and after exercise may be useful and effective (60,325,356). Additional evidence for this approach comes from the Behavior Change Consortium (275), which reported on screening procedures and complications from 11 physical activity interventions in more than 5500 middle-aged and older persons. The studies used minimal (e.g., health questionnaires such as the PAR-Q, measurement of blood pressure and pulse) or more extensive screening (e.g., medical examination) procedures, but no study reported a serious CHD event, suggesting that the former can be highly effective. Few data support the role of routine diagnostic exercise testing as an effective method for reducing the risk of exercise-related CHD events (122,137,211,362). Consultation with a medical professional and diagnostic exercise testing should be performed as medically indicated based on signs and symptoms of disease and according to clinical practice guidelines (20,122,136,241).

There are no randomized studies demonstrating the effectiveness of supervision by a well-trained fitness professional in reducing the risks of exercise, but the low risk of exercise-related complications in medically supervised exercise programs (14,359) supports the likelihood of benefit, particularly for novice exercisers who are at an elevated risk for exercise-related complications.

CONCLUSIONS

The ACSM recommends a comprehensive program of exercise including cardiorespiratory, resistance, flexibility, and neuromotor exercise of sufficient volume and quality as outlined in this document for apparently healthy adults of all ages. Reducing total time spent in sedentary pursuits and interspersing short bouts of physical activity and standing between periods of sedentary activity should be a goal for all adults, irrespective of their exercise habits. Exercise performed in this manner improves physical and mental health and/or fitness in most persons. However, a program of exercise that does not include all exercise components or achieves less than the recommended volumes (intensity, duration, and frequency) of exercise is likely to have benefit, particularly in habitually inactive persons. The exercise prescription is best adjusted according to individual responses because of the considerable individual variability in the response to a program of exercise. Exercise is beneficial only if a person engages in it. To this end, focusing on individual preferences and enjoyment and incorporating health behavior theory and behavior change strategies into exercise counseling and programs can enhance adoption and short-term maintenance of regular exercise, and these form an essential component of exercise counseling and programs. Effective strategies to reduce the musculoskeletal and CVD risks of exercise include screening for and educating about prodromal signs and symptoms of cardiovascular disease in novice and habitual exercisers, consultation with a health professional and diagnostic exercise testing as medically indicated, and attention to several elements of the exercise prescription including warming up, cooling down, a gradual progression of exercise volume and intensity, and proper training technique. The supervision of an experienced fitness professional can enhance adherence to exercise and likely reduces the risk of exercise in those with elevated risk of adverse CHD events. Adults, especially novice exercisers and persons with health conditions or disabilities, likely can benefit from consultation with a well-trained fitness professional.

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The authors base this revision on the painstaking efforts of members of the writing groups for the 1978, 1990, and 1998 versions of this Position Stand, who summarized in a clear and concise manner the latest scientific research with specific reference to application. The authors especially recognize the legacy of Dr. Michael L. Pollock, the chair of each of these writing groups, who initiated this Position Stand series, and whose pioneering research laid the foundation for the science of exercise prescription as it exists today. The authors thank Jay Cameron and Sarah Black for their valuable assistance in reference database development.

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