

Circulation

JOURNAL OF THE AMERICAN HEART ASSOCIATION



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Circulation 2004;109:2031-2041

DOI: 10.1161/01.CIR.0000126280.65777.A4

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75214

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Physical Activity and Exercise Recommendations for Stroke Survivors

An American Heart Association Scientific Statement From the Council on Clinical Cardiology, Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention; the Council on Cardiovascular Nursing; the Council on Nutrition, Physical Activity, and Metabolism; and the Stroke Council

Neil F. Gordon, MD, PhD, Cochair; Meg Gulanick, PhD, APRN, Cochair; Fernando Costa, MD; Gerald Fletcher, MD; Barry A. Franklin, PhD; Elliot J. Roth, MD; Tim Shephard, RN, MSN

Annually, 700 000 people in the United States suffer a stroke, or \approx 1 person every 45 seconds, and nearly one third of these strokes are recurrent.¹ More than half of men and women under the age of 65 years who have a stroke die within 8 years.¹ Although the stroke death rate fell 12% from 1990 to 2000, the actual number of stroke deaths increased by 9.9%. This represents a leveling off of prior declines.² Moreover, the incidence of stroke is likely to continue to escalate because of an expanding population of elderly Americans; a growing epidemic of diabetes, obesity, and physical inactivity among the general population; and a greater prevalence of heart failure patients.³ When considered independently from other cardiovascular diseases, stroke continues to be the third leading cause of death in the United States.

Improved short-term survival after a stroke has resulted in a population of an estimated 4 700 000 stroke survivors in the United States.¹ The majority of recurrent events in stroke survivors are recurrent strokes, at least for the first several years.⁴ Moreover, individuals presenting with stroke frequently have significant atherosclerotic lesions throughout their vascular system and are at heightened risk for, or have, associated comorbid cardiovascular disease.^{5,6} Accordingly, recurrent stroke and cardiac disease are the leading causes of mortality in stroke survivors.

Both coronary artery disease (CAD) and ischemic stroke share links to many of the same predisposing, potentially modifiable risk factors (hypertension, abnormal blood lipids and lipoproteins, cigarette smoking, physical inactivity, obesity, and diabetes mellitus), which highlights the prominent role lifestyle plays in the origin of stroke and cardiovascular

disease.^{5,7,8} Modification of multiple risk factors through a combination of comprehensive lifestyle interventions and appropriate pharmacological therapy is now recognized as the cornerstone of initiatives aimed at the prevention of recurrent stroke and acute cardiac events in stroke survivors.^{5,9}

Several important factors underscore the potential value of exercise training and physical activity in stroke survivors. Previous studies have demonstrated the trainability of stroke survivors and documented beneficial physiological, psychological, sensorimotor, strength, endurance, and functional effects of various types of exercise.^{10–23} Moreover, data from studies involving stroke and able-bodied subjects have documented the beneficial impact of regular physical activity on multiple cardiovascular disease risk factors and provided evidence that such benefits are likely to translate into a reduced risk for mortality from stroke and cardiac events.^{24–28} Although they require additional validation by randomized clinical trials and other appropriately designed studies, these observations make recommendations for stroke survivors to participate in regular physical activity highly compelling at the present time.

Unfortunately, stroke remains a leading cause of long-term disability in the United States.¹ Consequently, stroke survivors are often deconditioned and predisposed to a sedentary lifestyle that limits performance of activities of daily living, increases the risk for falls, and may contribute to a heightened risk for recurrent stroke and cardiovascular disease. Clearly, stroke survivors can benefit from counseling on participation in physical activity and exercise training. However, most healthcare professionals have limited experience and guidance in exercise programming for this diverse and escalating

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This statement was approved by the American Heart Association Science Advisory and Coordinating Committee on January 30, 2004. A single reprint is available by calling 800-242-8721 (US only) or by writing the American Heart Association, Public Information, 7272 Greenville Ave, Dallas, TX 75231-4596. Ask for reprint No. 71-0259. To purchase additional reprints: up to 999 copies, call 800-611-6083 (US only) or fax 413-665-2671; 1000 or more copies, call 410-528-4121, fax 410-528-4264, or e-mail kgray@lww.com. To make photocopies for personal or educational use, call the Copyright Clearance Center, 978-750-8400.

This article is being copublished in the April 27, 2004, issue of *Circulation* and the May 2004 issue of *Stroke*.

(*Circulation* 2004;109:2031-2041.)

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Circulation is available at <http://www.circulationaha.org>

DOI: 10.1161/01.CIR.0000126280.65777.A4

patient population. This scientific statement is intended to help bridge the current knowledge gap.

Poststroke Sequelae and Comorbid Conditions

The World Health Organization's International Classification of Functioning, Disability, and Health organizes the effects of conditions such as stroke into problems in the "body structure and function dimension" and in the "activity and participation dimension."²⁹ Body structure and function effects (known as "impairments"), such as hemiplegia, spasticity, and aphasia, are the primary neurological disorders that are caused by stroke. Activity limitations (also referred to as "disabilities") are manifested by reduced ability to perform daily functions, such as dressing, bathing, or walking. The magnitude of activity limitation is generally related to but not completely dependent on the level of body impairment (ie, severity of stroke).³⁰ Other factors that influence level of activity limitation include intrinsic motivation and mood, adaptability and coping skill, cognition and learning ability, severity and type of preexisting and acquired medical comorbidity, medical stability, physical endurance levels, effects of acute treatments, and the amount and type of rehabilitation training.^{31–33} Therapeutic interventions to improve sensorimotor performance after stroke vary considerably.³⁴ Although there is emerging evidence that rehabilitation can be effective in improving both intrinsic motor control and functional status, systematic trials comparing the relative effectiveness of various motor control intervention types generally have been few in number and suboptimal in design.

Although $\approx 14\%$ of stroke survivors achieve a full recovery in physical function, between 25% and 50% require at least some assistance with activities of daily living, and half experience severe long-term effects such as partial paralysis. Consequently, activity intolerance is common among stroke survivors, especially in the elderly.^{32,33} Ambulatory persons with a history of stroke may be able to perform at $\approx 50\%$ of peak oxygen consumption and 70% of the peak power output that can be achieved by age- and gender-matched individuals without a history of stroke. Such intolerance is likely due to several factors, including bed-rest-induced deconditioning, concomitant left ventricular dysfunction, the associated severity of neurological involvement (eg, flaccidity or developing spasticity of the lower extremity and/or impairment of the sensory function of the involved side, impaired trunk balance, spasticity or weakness of the afflicted upper or lower extremity, receptive aphasia, and mental confusion), and the increased aerobic requirements of walking.

Energy expenditure during gait in hemiplegic patients varies with the degree of weakness, spasticity, training, and bracing, but in general, the oxygen cost of walking (ie, oxygen consumption expressed in either absolute [$L \cdot \text{min}^{-1}$] or relative [$\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$] terms) is elevated in hemiplegic patients compared with that of able-bodied subjects of comparable body weight.^{35,36} Indeed, in some cases, the debilitating motor effects of a stroke can markedly reduce mechanical efficiency and increase the energy cost of walking up to 2 times that of able-bodied persons.³² Even common household tasks, such as bed making and vacuuming, are associated with considerably greater energy requirements

among poststroke women than among their healthy counterparts.³⁷

Collectively, the above-mentioned variables can create a vicious circle of further decreased activity and greater exercise intolerance, leading to secondary complications such as reduced cardiorespiratory fitness, muscle atrophy, osteoporosis, and impaired circulation to the lower extremities in stroke survivors. The latter may result in eventual thrombus formation, decubitus ulcers, or both. In addition, a diminished self-efficacy, greater dependence on others for activities of daily living, and reduced ability for normal societal interactions can have a profound negative psychological impact.

Stroke usually does not occur in isolation. Patients with stroke have a high prevalence of associated medical problems. These conditions may predate the stroke ("preexisting conditions"), occur for the first time after stroke ("poststroke complications"), or present as manifestations of preexisting medical conditions after stroke (eg, poststroke angina in patients with a history of CAD).⁶ In particular, cardiac disease has been reported to occur in up to 75% of stroke survivors.⁶ Because physical activity places greater energy demands on the cardiovascular system of hemiplegic patients than on that of able-bodied subjects, stroke survivors with preexisting cardiac disease may be at an increased risk for exertion-related adverse cardiac complications.^{32,35–37}

This situation has several important implications for individuals with stroke and the professionals who counsel them. Preexisting or poststroke cardiovascular conditions can delay or inhibit participation in a therapeutic exercise program, complicate the rehabilitation and long-term poststroke course of care, and limit the ability of the patient to perform functional activities independently.^{38–40} It has been suggested that stroke patients are more disabled by associated cardiac disease than by the stroke itself.⁴¹ Stroke patients have a known heightened risk of secondary cardiac complications and recurrent stroke, which makes the poststroke period a particularly important time to implement stroke secondary prevention interventions.^{5,33,38–40,42,43}

Goals of Prescribed Physical Activity/Exercise

Traditionally, the physical rehabilitation of individuals typically ended within several months after stroke because it was believed that most if not all recovery of motor function occurred during this interval. Nevertheless, recent research studies have shown that aggressive rehabilitation beyond this time period, including treadmill exercise with or without body weight support, increases aerobic capacity and sensorimotor function.^{14,16,17,44}

Consequently, rehabilitation programs designed to optimize functional motor performance in stroke survivors increasingly have incorporated aerobic exercise training, with and without partial body weight-supported walking, to improve strength and timing of muscle activations and cardiorespiratory fitness.^{11,14–17,20,21,44,45} Generally, this is complemented by specialized training to improve skill and efficiency in self-care, occupational, and leisure-time activities. In addition to improvement in measures of quality of life, functional capacity and mobility (eg, increasing gait velocity), neurological impairment, and motor function (eg, low-

ering the energy cost of a hemiparetic gait), 3 major rehabilitation goals for the stroke patient are preventing complications of prolonged inactivity, decreasing recurrent stroke and cardiovascular events, and increasing aerobic fitness.

To achieve the first rehabilitation goal, the stroke patient needs to initiate a physical conditioning regimen designed to regain prestroke levels of activity as soon as possible.⁴⁶ For inpatients, simple exposure to orthostatic or gravitational stress (ie, intermittent sitting or standing) during hospital convalescence has been shown to obviate much of the deterioration in exercise tolerance that normally follows a cardiovascular event or intervention.⁴⁷ Shortly after hospital discharge, the continuum of exercise therapy may range from remedial gait retraining in hemiparetic stroke patients to supervised or home-based walking or treadmill training programs.¹¹

The second rehabilitation goal for the stroke survivor is to prevent recurrent stroke and cardiovascular events that occur with greater frequency in the patient who has had a stroke.⁴⁶ A reduction of risk factors can decrease the incidence of recurrent strokes and coronary events. An aerobic conditioning program can enhance glucose regulation and promote decreases in body weight and fat stores, blood pressure (particularly in hypertensive patients), C-reactive protein, and levels of total blood cholesterol, serum triglycerides, and low-density lipoprotein cholesterol.⁴⁸ Exercise also increases high-density lipoprotein cholesterol and improves blood rheology, hemostatic variables, and coronary artery endothelial function.⁴⁹ These findings are consistent with the growing body of evidence that interventions that promote plaque stability, favorable changes in vascular wall function, or both have important implications for the medical management of patients after a stroke or other vascular event.⁵⁰

The third rehabilitation goal for this patient subset should be to improve aerobic fitness, notwithstanding residual functional limitations. Evidence is accumulating that stroke risk can be reduced with regular leisure-time physical activity in multiethnic individuals of all ages and both sexes.²⁸ Recently, the association between baseline cardiorespiratory fitness and stroke mortality was investigated in 16 878 apparently healthy men, aged 40 to 87 years, with the Aerobics Center Longitudinal Study database.²⁵ During an average of 10 years of follow-up, men in the moderate- and high-fitness groups had a 63% and 68% lower risk of stroke death, respectively, than men who were in the lowest-fitness group at baseline. Moreover, the inverse association between aerobic fitness and stroke mortality remained even after statistical adjustments for cigarette smoking, alcohol consumption, body mass index, hypertension, diabetes mellitus, and a family history of CAD. Although extrapolation of these data to the prevention of secondary strokes is unproven, it appears prudent to include improved cardiorespiratory fitness as a major rehabilitation goal.

Cardiorespiratory Response to Acute Exercise in Stroke Survivors

The cardiac response to acute exercise among individuals who have had a stroke has been documented in a small

number of studies. Stroke patients have been shown to achieve significantly lower maximal workloads and heart rate and blood pressure responses than control subjects during progressive exercise testing to volitional fatigue.^{51,52} Other earlier studies, which used various adapted ergometry devices or exercise protocols with smaller sample sizes, yielded similar findings.^{37,53–55} In general, oxygen uptake at a given submaximal workload in stroke patients is greater than in healthy subjects, possibly because of reduced mechanical efficiency, the effects of spasticity, or both. In contrast, peak oxygen uptake is reduced in these stroke patients.

Effects of Exercise Training and Rehabilitation Programs in Stroke Survivors

The link between exercise training and improved cardiovascular fitness and health has been well established in the general population. Whether the training-induced health and fitness benefits can be extrapolated to persons who are disabled by stroke remained unclear until recently. Evidence now suggests that the exercise trainability of stroke survivors may be comparable, in many ways, to that of their age-matched, healthy counterparts.

In a randomized, controlled trial that involved 42 hemiparetic stroke survivors, vigorous aerobic exercise training 3 times per week for 10 weeks evoked significant improvements in peak oxygen consumption and workload, submaximal exercise blood pressure response, exercise time, and sensorimotor function; moreover, the latter was significantly related to improvement in aerobic capacity.¹⁷ The findings demonstrated that stroke patients can increase their cardiovascular fitness by a magnitude that is similar to that of healthy older adults who engage in endurance training programs.

The effect of 6 months of treadmill aerobic exercise training on the energy expenditure and cardiovascular demands of moderate aerobic exercise with a graded treadmill for ambulation was studied in stroke patients with chronic hemiparetic gait.¹⁶ The program elicited significant reductions in submaximal energy expenditure; these reductions were progressive with continued exercise training. An important implication of this study was that it extended the observation of a potential benefit from task-oriented aerobic exercise training to the clinically relevant task of hemiparetic ambulation. The data suggest that aerobic exercise training and improved cardiovascular fitness might enable activities of daily living to be performed at a lower percentage of the aerobic capacity.

Recently, the effects of a 1-hour-per-day, 3-day-per-week, 12-week exercise program of combined cardiovascular, strength, and flexibility training was studied in 35 stroke patients with multiple comorbidities.¹⁸ Compared with controls, the exercise group demonstrated significant gains in peak oxygen uptake and strength and improvements in body composition.

The effect of a 6-month home exercise training program was investigated in a prospective, randomized, controlled clinical trial that involved 88 men with CAD and disability, two thirds of whom were stroke survivors.⁵⁶ The subjects demonstrated significant increases in peak left ventricular

ejection fraction and high-density lipoprotein cholesterol and decreases in resting heart rate and total serum cholesterol with exercise training.

In a 12-week cycle-ergometer training study, exercise capacity and self-concept improved in 7 hemiparetic stroke patients.¹⁰ However, there were no direct measurements of cardiorespiratory fitness, and motor function improvements were characterized by subjective descriptions rather than standardized functional evaluations.

Collectively, these findings support the use of regular aerobic exercise to improve cardiovascular health and fitness after stroke, which is consistent with recent consensus statements on exercise for able-bodied individuals.^{24,57–59} Strength training also has been found to have beneficial effects in patients with stroke. Several studies have shown strong associations between paretic knee-extension torque and locomotion ability and between both hip flexor and ankle plantar flexor strength of the paretic limb and walking speed after stroke.^{36,60,61}

A recent investigation evaluated the effects of a 12-week, twice-per-week, progressive resistance-training program on muscle strength, gait, and balance in stroke subjects.²² Lower-limb strength increased 68% on the affected side and less so on the intact side. Transfer time, motor performance, and static and dynamic balance also showed improvements. These results confirmed those of a previous study that showed benefits of strength training of the hemiparetic knee.¹⁹

Traditional stroke rehabilitation programs emphasize functional training as a means to help the individual gain and maintain as much independence as possible. Training in the performance of mobility and personal care tasks, together with attempts to improve muscle strength and coordination, continue to form the central areas of focus of most rehabilitation programs. Whether these exercise-training programs enhance aerobic fitness is not clear. The heightened degree of physical skill required to perform these tasks and the physiological stress placed on the deconditioned individual's cardiovascular system while performing activities of daily living suggest that a physiological training effect is likely to occur when these movements are performed in a sustained and systematic manner.⁶² Because increased levels of physical activity are associated with a reduced risk for stroke and cardiovascular disease and enhanced physical and psychosocial performance, such interventions performed in a stroke rehabilitation program may have a favorable effect on the prevention of recurrent stroke and cardiovascular events.

There are no published investigations to support the assertion that the interventions with regard to activities of daily living that are included in stroke rehabilitation programs, as currently practiced, actually reduce the risk for recurrent stroke and cardiovascular disease. Moreover, the precise interventions that are used are believed to vary considerably among stroke rehabilitation programs. However, one study of cardiac monitoring of stroke patients in rehabilitation indicated that heart rates in stroke patients during physical therapy sessions were generally in the target heart rate ranges for conditioning programs, which suggests that patients may have derived a cardiovascular training effect from their functional exercise program.⁶² However, the durations of

exertional tachycardia and changes in fitness were not determined; thus, the potential to elicit a training effect could not be established definitively.

A recent study evaluated the relative cardiovascular stress of physical therapy and occupational therapy sessions in 20 patients undergoing a stroke rehabilitation program.⁶³ The time per session in which the achieved heart rate was within the prescribed target heart rate zone was found to be extremely low, which suggests that these sessions elicited inadequate cardiovascular stress to induce a training effect.

Both of these last 2 studies found that activities that evoked the greatest heart rate increases were performed in the upright position and involved transitional movements.^{62,63} Approximately one third to one half of the treatment time was apportioned to standing activities.

Some researchers have raised concerns that occupational therapy sessions for poststroke patients may involve periods of intense isometric work that induce excessive cardiovascular demands.⁵⁵ In contrast, others have suggested that workloads for stroke patients who participated in physical therapy were appropriate, evoking relatively low levels of cardiovascular stress.^{62,63} Moreover, it has been theorized that the predominantly static nature of most stroke rehabilitation programs might contribute to the low physical endurance of poststroke patients.⁶⁴

Extrapolation of what is known about the training effect of regular exercise by able-bodied individuals suggests that certain levels of exercise that are achieved during many stroke rehabilitation programs may improve aerobic fitness and thereby help reduce the risk for recurrent stroke and cardiovascular events. Accordingly, professionals who design and conduct stroke rehabilitation programs should consider allocating more time to aerobic exercise training to optimize patient outcomes.

The Preexercise Evaluation

Exercise is a normal human function that can be undertaken with a high level of safety by most people, including stroke survivors. However, exercise is not without risks, and the recommendation that stroke survivors participate in an exercise program is based on the premise that the benefits outweigh these risks. Therefore, the foremost priority in formulating the exercise prescription is to minimize the potential adverse effects of exercise via appropriate screening, program design, monitoring, and patient education.

As is the case for the general population, the major potential health hazards of exercise for stroke survivors are likely to include musculoskeletal injury and sudden cardiac death. Depending on the severity of disability and other coexisting medical conditions, certain patients may need to participate in a medically supervised exercise program. However, before embarking on a physical conditioning regimen, it is recommended that all stroke survivors undergo a complete medical history, usually the most important part of the preexercise evaluation, and a physical examination aimed at the identification of neurological complications and other medical conditions that require special consideration or constitute a contraindication to exercise.

From a preexercise evaluation perspective, the most serious complication of exercise participation, although rare, is sudden cardiac death. Although habitual physical activity is associated with an overall reduction in the risk of sudden cardiac death in the general adult population and the likelihood of experiencing a fatal cardiac event during exercise training is extremely small, it is well established that exercise can precipitate malignant ventricular arrhythmias.^{65–67} Moreover, several studies have now shown that the transiently increased risk of cardiac arrest that occurs during exercise results primarily from the presence of preexisting CAD, especially in habitually sedentary adults.^{68,69} Because up to 75% of stroke victims have coexisting cardiac disease, and 20% to 40% of asymptomatic stroke patients may have abnormal tests for silent cardiac ischemia,^{6,48,70} it is recommended that stroke patients undergo graded exercise testing with electrocardiograph (ECG) monitoring as part of a medical evaluation before beginning an exercise program.^{67,71}

As discussed in another American Heart Association/American Stroke Association scientific statement, there are limited data on the safety of graded exercise testing after a stroke.⁷⁰ Available data suggest that graded exercise testing is likely to be associated with an acceptably low risk of serious cardiovascular complications in stroke patients.⁷⁰

Generally, graded exercise testing in stroke patients should be conducted in accordance with contemporary guidelines as detailed elsewhere.^{63,71} Briefly, the exercise test modality/protocol for the stroke survivor is selected to optimally assess functional capacity and the cardiovascular response to exercise. The test should evaluate the heart rate, rhythm, and ECG response to exercise as well as the systolic and diastolic blood pressure response. Careful assessment of the subjective response (especially cardiac symptoms) should be done. The testing mode should be selected or adapted to the needs of the stroke survivor. Often, a standard treadmill walking protocol can be used (with the aid of handrails). The Bruce protocol (or a modified version) is appropriate for many subjects, with a progressive workload achieved by increasing speed and grade of the treadmill.⁷² For some subjects, however, other modes are needed, and special protocols are available for stroke survivors, especially those with hemiplegia or paresis.⁵⁶ Many testing protocols use arm cycle ergometry with the subject seated to optimize the load.⁵⁶ Other protocols use arm-leg or leg cycle ergometry.

Thus, if flexibility and adaptability are used in the selection of testing protocols, most stroke survivors who are deemed stable for physical activity can undergo exercise testing. Such testing helps determine the subject's exercise capacity and identify associated adverse signs or symptoms that may affect the safety of an exercise program. For patients with disabilities that preclude exercise testing, pharmacological stress testing should be considered.⁷⁰

No studies have specifically addressed the issue of how soon after a stroke graded exercise testing can be performed safely. Until such data become available, good clinical judgment should be foremost in deciding the timing of graded exercise testing after stroke and whether to use a submaximal or symptom-limited maximal test protocol. In the absence of definitive evidence, it may be prudent to follow guidelines

similar to those recommended for post-myocardial infarction patients and use submaximal protocols (with a predetermined end point, often defined as a peak heart rate of 120 bpm, or 70% of the age-predicted maximum heart rate, or a peak metabolic equivalent [MET] level of 5) if graded exercise testing is performed during the first 14 to 21 days after stroke.⁷¹ In the absence of definitive evidence, it also appears prudent to consider a systolic blood pressure >250 mm Hg and/or diastolic blood pressure >115 mm Hg an absolute (rather than relative) indication to terminate a graded exercise test in a stroke patient.⁷¹ As is recommended for patients with CAD, the upper limit of the target heart rate range for subsequent exercise training should generally be at least 10 bpm below the heart rate associated with blood pressure responses of this magnitude.⁶⁷

From a practical standpoint, it may not be possible, for a variety of reasons, for many stroke patients to perform an exercise test before they begin an exercise program. For patients for whom an exercise ECG is recommended but not performed, lighter-intensity exercise should be prescribed. The reduced exercise intensity may be compensated for by increasing the training frequency, duration, or both.

In summary, evaluation of the stroke survivor for an exercise program is multidimensional and includes a careful medical history and physical examination. Specific attention should focus on the results of an exercise test, if available. If the evaluation is conducted with the aforementioned considerations, an exercise program can be highly beneficial and safe for the stroke survivor.

Recommendations for Exercise Programming

Exercise programming recommendations for stroke survivors are summarized in Table 1. Prescribing exercise for the stroke patient is comparable in many ways to prescribing medications; that is, one recommends an optimal dosage according to individual needs and limitations. Aerobic training modes may include leg, arm, or combined arm-leg ergometry at 40% to 70% of peak oxygen consumption or heart rate reserve,⁷³ with perceived exertion used as an adjunctive intensity modulator.⁷⁴ The recommended frequency of training is 3 to 7 days a week, with a duration of 20 to 60 min/d of continuous or accumulated exercise (eg, ≥10-minute bouts), depending on the patient's level of fitness. Intermittent training protocols may be needed during the initial weeks of rehabilitation because of the extremely deconditioned level of many convalescing stroke patients.⁷³

Treadmill training appears to offer 3 distinct advantages in the exercise rehabilitation of persons who have had a stroke. First, it requires the performance of a task required for everyday living, namely, walking, which should enhance the generalizability of training effects. Second, the use of hand-rail support and "unweighting" devices (ie, harnesses that serve to "lift" patients, effectively decreasing their weight) allows patients to walk on a treadmill who might otherwise be unable to exercise. Third, in patients with residual gait deviations, exercise intensity can be augmented by increasing the treadmill grade while maintaining a comfortable speed.

To maximize the generalizability of the conditioning response to daily activities, adjunctive upper-body and

TABLE 1. Summary of Exercise Programming Recommendations for Stroke Survivors*

Mode of Exercise	Major Goals	Intensity/Frequency/Duration
Aerobic		
<ul style="list-style-type: none"> Large-muscle activities (eg, walking, treadmill, stationary cycle, combined arm-leg ergometry, arm ergometry, seated stepper) 	<ul style="list-style-type: none"> Increase independence in ADLs Increase walking speed/efficiency Improve tolerance for prolonged physical activity Reduce risk of cardiovascular disease 	<ul style="list-style-type: none"> 40%–70% peak oxygen uptake; 40%–70% heart rate reserve; 50%–80% maximal heart rate; RPE 11–14 (6–20 scale) 3–7 d/wk 20–60 min/session (or multiple 10-min sessions)
Strength		
<ul style="list-style-type: none"> Circuit training Weight machines Free weights Isometric exercise 	<ul style="list-style-type: none"> Increase independence in ADLs 	<ul style="list-style-type: none"> 1–3 sets of 10–15 repetitions of 8–10 exercises involving the major muscle groups 2–3 d/wk
Flexibility		
<ul style="list-style-type: none"> Stretching 	<ul style="list-style-type: none"> Increase ROM of involved extremities Prevent contractures 	<ul style="list-style-type: none"> 2–3 d/wk (before or after aerobic or strength training) Hold each stretch for 10–30 seconds
Neuromuscular		
<ul style="list-style-type: none"> Coordination and balance activities 	<ul style="list-style-type: none"> Improve level of safety during ADLs 	<ul style="list-style-type: none"> 2–3 d/wk (consider performing on same day as strength activities)

ADLs indicates activities of daily living; RPE, rating of perceived exertion; and ROM, range of motion.

*From references 67, 71, 73, 75, 94, 95, and 96.

Recommended intensity, frequency, and duration of exercise depend on each individual patient's level of fitness. Intermittent training sessions may be indicated during the initial weeks of rehabilitation.

resistance-training programs are also recommended for clinically stable stroke patients. In one study, 6 weeks of bilateral arm training with rhythmic auditory cueing improved several key measures of sensorimotor impairments, functional ability (performance time), and functional use in patients with chronic upper-extremity hemiparesis.²³ Although there are no accepted guidelines for determining when and how to initiate resistance training after ischemic or hemorrhagic stroke,¹³ it may be prudent to prescribe 10 to 15 repetitions (ie, higher repetitions with reduced loads) for each set of exercises rather than 8 to 12 repetitions, similar to that recommended for post-myocardial infarction patients.⁷⁵ Such regimens should be performed 2 to 3 days per week and include a minimum of 1 set of at least 8 to 10 exercises that involve the major muscle groups (arms, shoulders, chest, abdomen, back, hips, and legs). Some studies suggest that such regimens may promote gains in strength and gait velocity and that eccentric training may be more suitable for stroke patients than concentric training.^{12,19} Adjunctive flexibility and neuromuscular training to increase range of motion of the involved side, prevent contractures, and increase activities of daily living are also recommended.⁷³

Barriers to Physical Activity and Exercise Training in Stroke Patients

The evaluation of physiological and emotional barriers to poststroke physical activity requires an evaluation of primary factors of stroke severity, comorbidities, and clinical deficits, as well as secondary factors of familial support, depression, poststroke fatigue, social integration, and cultural issues. Professional assessment and intervention relative to primary and secondary factors are important to help prevent a cycle of diminished motivation, loss of engagement in activity, decon-

ditioning, subsequent related acute illness (such as pneumonia), and a resultant need for temporary reinitiation of acute therapy.⁷⁶

As discussed previously, the initial step to implementing an effective exercise regimen for poststroke patients is a medical history and physical examination to identify physiological barriers. The combination of comorbidities and neurological deficits that are unique to each stroke survivor requires an individual approach to ensure that the patient can safely and effectively engage in a physical activity program. The evaluation of a stroke survivor for an exercise program involves acquisition of data from both the patient and his or her caregiver.⁷⁷

In addition to components of the preexercise evaluation already outlined, the neurological examination should clarify the cognitive state, and the Folstein Mini Mental Status examination can be a useful ancillary test in this regard.⁷⁸ The degree of communication deficit (ie, aphasia, both expressive and receptive) will have a significant impact on the success of any rehabilitative program, and alternative methods of communication may need to be sought and practiced in preparation for ongoing therapy.

A complete understanding by the patient, family, and clinical team of mutually derived goals, current capabilities, and safety issues will help to circumvent interpersonal barriers to treatment and should be integrated into the development of a therapeutic plan.¹¹ In the context of defining therapy goals for the poststroke patient, it is essential that the family be integrated into the process as early as possible. Early involvement of the family unit has been strongly correlated with patient adherence to therapy, better understanding between patient and caregiver of achievable outcomes, and improved communication between patient and

caregivers.⁷⁹ To facilitate optimal outcomes from an exercise-based stroke rehabilitation program, an assessment of familial support should be undertaken.

With the aging of the population and the escalation of healthcare costs, more of the burden of long-term care is being placed on family, friends, community, or religious congregations. Of all patients needing home care after an illness, ≈80% receive at least part of their care from a family member. The significance of the assessment, integration, and care of the lay caregiver cannot be overemphasized. The stress of caring for the stroke patient can be overwhelming and frightening. The fatigue and depression of the stroke patient is translated directly to caregivers and, thus, the effectiveness of a prescribed exercise program will depend on them as well. When applicable, an assessment of family functioning with a tool such as the McMaster Family Assessment Device may serve to enhance adherence and improve long-term outcomes.^{80,81}

A primary barrier to any type of poststroke therapy is depression. The incidence of poststroke depression ranges from 18% to 68%.⁸² The initial steps of designing a physical activity regimen for stroke patients should include an assessment for depression. Depression screening can be performed with 1 of 4 depression scales recommended in the Agency for Health Care Policy and Research Guidelines. These are the Beck depression inventory,⁸³ the Center for Epidemiologic Studies depression scale (CES-D),⁸⁴ the geriatric depression scale (GDS),⁸⁵ and the Hamilton depression scale.⁸⁶ Screening scales should be administered by a professional knowledgeable about the scale, its application, and its interpretation. If warranted, further assessment and treatment should be coordinated by a mental health professional, preferably one who has experience in geriatrics and stroke care. The proper assessment for depression will affect patient and caregiver motivation positively. When prescribed, the use of antidepressants should be evaluated regularly in an effort to prevent exacerbation of sleep disturbance or poststroke fatigue.

Poststroke fatigue, with or without depression, is reported to occur in 39% of patients but is relatively understudied in the stroke population.⁸⁷ Without an assessment of fatigue symptoms, attempts at implementing a physical conditioning regimen for poststroke patients may prove difficult and frustrating. A thorough assessment for fatigue syndromes may help the clinician differentiate between neurological and physiological fatigue. The patient should have an understanding that neurological fatigue syndromes may never be resolved completely and that long-term adaptation in activity routines may be required.

For patients who experience fatigue syndromes, an evaluation of temporality (ie, sudden versus persistent) and intensity will assist in determining the optimal duration and intensity for exercise and physical activity. Although there are relatively few clinical trials in the treatment of poststroke fatigue, at least 1 study has demonstrated that low-intensity aerobic exercise over a period of 6 months will improve cardiac function and reduce energy demands in patients with hemiparetic gait, thus preventing deconditioning and the associated consequences of physical inactivity.¹⁵

Although certain poststroke complications are prevented by physical conditioning, leisure-time activities may also be helpful in this regard. Such activities are part of a process of socialization. As a person grows older and experiences cognitive or physical limitations, they tend to give up these activities, which in turn may lead to social withdrawal and isolation. This tendency may be compounded in the stroke patient. Because of difficulty with mobility, perceived social stigma related to physical or cognitive deficits, or depression, many stroke patients become socially isolated. Social isolation is also strongly correlated with poststroke depression. When family members are primary caregivers for the stroke survivor, they too may become socially isolated, which will further limit the potential venues for physical activity and exercise.

When withdrawn socially, stroke patients are not likely to venture into the neighborhood for walks, use the public swimming pool for low-impact aquatic training, or travel to a local gym for exercise classes. Studies have shown that even in stroke survivors with a significant degree of physical recovery, social isolation was still evident.^{80,88} Many stroke patients will not have equipment or facilities in their home to sustain interest in an exercise program in the long term. They will need to seek assistance, equipment, and facilities in the community. To enhance exercise compliance, the issue of social isolation will need to be actively addressed and resolved.

It is a standard in a caring and empathetic clinical practice to be aware of and facilitate cultural diversity. In creating and implementing any type of recovery program for the stroke survivor, it is necessary to be aware of cultural differences that may affect acceptance or adherence. It is unlikely that one specific set of recommendations could guide clinicians through the cultural diversity they are likely to experience in practice. However, the design and implementation of a physical exercise regimen should be sensitive to cultural differences in modesty, assertiveness, or expected social roles. The integration of patient and family cultural norms will help create a program that is more likely to succeed over the long term.

The complex interplay between physiological and emotional barriers to continuing recovery after a stroke demand creative and individualized rehabilitative programs to be designed and implemented by a multidisciplinary team. The relevant clinical, emotional, and social variations present in each stroke survivor preclude the application of a template to poststroke rehabilitation. When applicable tools are used to assess the individual for physiological and emotional barriers and known and adapted techniques to remove or ameliorate such barriers are applied, each patient is best prepared to reach their optimal state of function and well-being.

Importance of Comprehensive Stroke and Cardiovascular Disease Risk Reduction

Persons who have previously had a stroke are at a markedly increased risk for a recurrent stroke. Although most strokes are potentially preventable, especially ischemic strokes, stroke remains the third-leading cause of death in the United States. Moreover, recent epidemiological data suggest a

substantial leveling off of prior declines in stroke mortality rates and a possible increase in stroke incidence.⁸⁹

Ischemic strokes account for ≈88% of all strokes. Risk factors for ischemic stroke may be classified into 3 major groups: nonmodifiable risk factors (including age, race, gender, and family history); well-documented modifiable risk factors (including previous transient ischemic attack, carotid artery disease, atrial fibrillation, CAD, other types of cardiac disease, hypertension, cigarette smoking, hyperlipidemia, diabetes mellitus, and sickle cell disease); and less well-documented, potentially modifiable risk factors (including physical inactivity, obesity, alcohol abuse, hyperhomocysteinemia, drug abuse, hypercoagulability, hormone replacement therapy, oral contraceptive use, and inflammatory processes).^{5,7} Because atherosclerosis is the most common underlying cause of ischemic stroke, it is not surprising that all of the major potentially modifiable risk factors for CAD are included in the above listing of stroke risk factors.

As is the case with CAD, there is substantial evidence from clinical trials that a first or recurrent stroke can often be prevented.⁴² A key to stroke prevention is the control of multiple stroke risk factors via comprehensive lifestyle modification and the appropriate use of pharmacological therapy (and carotid endarterectomy, as indicated).^{5,7,42} Intensive risk factor management can be expected to lessen the risk for atherothrombotic events in the coronary, limb, cervicocranial, and other arterial territories. Accordingly, published national guidelines are available for the prevention of stroke and other types of atherosclerotic cardiovascular disease.^{5,8,9,42}

Thus, current evidence provides a strong rationale for the long-term intensive control of multiple risk factors as an essential strategy to reduce the risk both for recurrent stroke and for acute cardiac events in stroke survivors. Physical activity and exercise training recommendations for stroke survivors should be viewed as one important component of a comprehensive stroke risk-reduction program.

Despite the recognition of potentially modifiable risk factors for recurrent stroke and the availability of national authoritative guidelines for risk factor management, recent research has identified a large “treatment gap” between recommended therapies for patients at heightened risk for stroke and cardiovascular events and the care these patients actually receive.⁸⁹ Taken in aggregate, existing data show that fewer than 50% of patients reliably have their risk factors assessed, treated, or controlled.⁸⁹ In one recent study of stroke patients, data from a stroke clinic at a tertiary referral medical center in the United States indicated that during a 2-year period, 90% of patients who were overweight at their initial evaluation remained overweight, only 51% of hypertensive patients had their blood pressure under adequate control, serum lipids and lipoproteins remained abnormal in 55% of patients, none of the smokers quit smoking, and few patients modified their dietary or exercise practices.⁹⁰ Clearly, there is an urgent need to bridge the treatment gap by developing and implementing approaches that provide all stroke survivors with affordable access to effective, comprehensive stroke risk-reduction interventions.⁹¹

Future Directions

Patients afflicted with stroke commonly experience a constellation of challenges that include a reduced functional capacity, activity intolerance, muscle atrophy, partial paralysis, residual gait deviations, associated symptomatology, depression, anxiety, job/economic stress, and, for some, an overwhelming sense of uncertainty. Several variables may influence the magnitude of these deficits. These include age, gender, convalescent-induced deconditioning, risk status, the associated severity of neurological involvement, concomitant CAD and its sequelae, comorbid conditions (eg, diabetes, pulmonary disease, and osteoporosis), medications, time from the acute cerebrovascular event, the degree of social support, and patient compliance with a prescribed rehabilitation regimen (if one is even provided).

Because of the vagaries of the atherosclerotic process and the multitude of physiological, clinical, and psychosocial variables that may influence the effects of physical activity on the cerebrovascular and cardiovascular systems, our ability to predict outcomes in stroke patients remains imperfect. Some research questions yet remaining include:

1. What is the influence of exercise training on quality of life in patients who suffer the consequences of stroke, including those with residual gait instability?
2. What is the cost-effectiveness of structured exercise programs in persons with a previous stroke?
3. Is improved aerobic fitness associated with a reduction in secondary strokes?
4. Are the health benefits associated with accumulated exercise (eg, several short bouts of aerobic training) generalizable to the deconditioned patient with stroke, both within the first 3 to 6 months after the acute event and remotely thereafter?
5. Are there clinical, neurological, and body habitus characteristics that can identify patients who would be more likely to benefit from “unweighted” as opposed to conventional treadmill walking?
6. Can regular exercise, by reducing the secondary complications of activity intolerance, decrease the need for cardiovascular and/or neurological medications and prevent or reduce the incidence and duration of recurrent hospitalizations in patients with stroke?
7. Does the risk of vigorous physical activity exceed the benefit in some patient subsets, with specific reference to cerebrovascular, cardiovascular, and musculoskeletal complications?
8. How does the principle of training specificity apply to the stroke patient in light of the afflicted upper or lower extremity and the impairment of sensory function of the involved side?
9. Is there an optimal stress test methodology for stroke patients that provides a relatively high sensitivity and specificity for concomitant CAD?
10. What are the best approaches for integrating exercise programming into a comprehensive risk-reduction program for stroke survivors?
11. What are the most cost-effective models for bridging the treatment gap in stroke survivors?
12. Can physician-supervised, nurse–case-managed comprehensive risk-reduction programs be implemented successfully in daily medical practice for stroke survivors?

TABLE 2. Physical Activity and Exercise Recommendations for Stroke Survivors: Summary of Key Points**Stroke survivors:**

- Improved short-term survival after stroke has resulted in a population of more than 4 700 000 stroke survivors in the United States.¹
- Recurrent stroke and cardiovascular disease are the leading causes of mortality in stroke survivors.^{5,6}
- Physical activity remains a cornerstone in the current armamentarium for risk factor management for the prevention and treatment of stroke and cardiovascular disease.^{24,57–59}
- Activity intolerance is common among stroke survivors, especially the elderly. Their sedentary lifestyle puts them at risk for recurrent stroke and cardiovascular disease.^{32,33}
- Stroke patients achieve significantly lower maximal workloads and heart rate/blood pressure responses than controls during progressive exercise testing.^{51,52}
- Many factors influence activity level after stroke, including physical, mental, and emotional status.^{31–33} Stroke patients may be more disabled by associated cardiac disease than by the stroke itself.⁴¹
- Energy expenditure during walking in hemiplegic patients varies with degree of altered body structure and function but is generally elevated, often up to 2 times that of able-bodied persons walking at the same submaximal speed.³²

Benefits of aerobic conditioning:

- Stroke survivors can benefit from counseling on participation in physical activity and exercise training.^{24–28}
- Research studies show that aggressive rehabilitation beyond the usual 6-month period increases aerobic capacity and sensorimotor function.^{14,16,17,44}
- An aerobic exercise program can improve multiple cardiovascular risk factors and thereby have important implications for the medical management of stroke survivors.^{48–50}
- Evidence is accumulating that stroke risk can be reduced with regular leisure-time physical activity in multiethnic individuals of all ages and both sexes.²⁸
- Evidence now suggests that the exercise trainability of stroke survivors may be comparable to that of age-matched healthy counterparts.^{10,16–18,56}
- Extrapolation of what is known about the training effects of regular exercise by able-bodied individuals suggests that certain levels of exercise that are achieved during many stroke rehabilitation programs may improve aerobic fitness.

Preexercise evaluation:

- It is recommended that all stroke survivors undergo a preexercise evaluation (complete medical history and physical examination, usually including graded exercise testing with ECG monitoring) before they initiate an exercise program.^{6,48}
- When undergoing exercise testing, the testing mode should be selected or adapted to the needs of the stroke survivor (eg, use of handrails, arm cycle ergometry, arm-leg or leg cycle ergometry).^{56,72}

Recommendations for exercise programming:

- Table 1 summarizes exercise-programming recommendations for stroke survivors. Treadmill walking is highly advantageous as the aerobic exercise mode, with inclusion of resistance, flexibility, and neuromuscular training.
- The combination of comorbidities, neurological deficits, and emotional barriers unique to each stroke survivor requires an individual approach to safe exercise programming.
- For patients unable to perform a graded exercise test, light-to-moderate rather than vigorous exercise should be prescribed, with a greater training frequency, duration, or both to compensate for the reduced intensity.
- Subsets of stroke survivors (eg, those with depression, fatigue syndrome, poor family support, or communication, cognitive, and motor deficits) will require further evaluation and subsequent specialization of their rehabilitation program.¹¹
- To enhance exercise compliance, the issues of family support and social isolation need to be addressed and resolved.
- Physical activity and exercise training recommendations for stroke survivors should be viewed as one important component of a comprehensive stroke and cardiovascular risk reduction program.

Table 2 summarizes the key points addressed in this statement. Physical activity remains a cornerstone in the current armamentarium of risk-reduction therapies for the prevention and treatment of stroke. The fervor of the physician's recommendation appears to be the single most powerful predictor of participation in an exercise-based risk-reduction program.⁹² Indeed, a recent study found that physician recommendations to exercise resulted in a doubling of the likelihood that stroke survivors would exercise.⁹³ This cost-effective intervention, which is now strongly supported by sound research, holds tremendous promise. The challenge for healthcare providers is to bring this promise to fruition.

References

1. American Heart Association. *Heart Disease and Stroke Statistics—2003 Update*. Dallas, Tex: American Heart Association; 2002.
2. Brown RD, Whisnant JP, Sicks JD, et al. Stroke incidence, prevalence, and survival: secular trends in Rochester, Minnesota, through 1989. *Stroke*. 1996;27:373–380.
3. Gillum RF, Sempos CT. The end of the long-term decline in stroke mortality in the United States? *Stroke*. 1997;28:1527–1529.
4. Vickrey BG, Rector TS, Wickstrom SL, et al. Occurrence of secondary ischemic events among persons with atherosclerotic vascular disease. *Stroke*. 2002;33:901–906.
5. Wolf PA, Clagett GP, Easton JD, et al. Preventing ischemic stroke in patients with prior stroke and transient ischemic attack: a statement for healthcare professionals from the Stroke Council of the American Heart Association. *Stroke*. 1999;30:1991–1994.
6. Roth EJ. Heart disease in patients with stroke: incidence, impact, and implications for rehabilitation, I: classification and prevalence. *Arch Phys Med Rehabil*. 1993;74:752–760.
7. Goldstein LB, Adams R, Becker K, et al. Primary prevention of ischemic stroke: a statement for healthcare professionals from the Stroke Council of the American Heart Association. *Circulation*. 2001;103:163–182.
8. Pearson TA, Blair SN, Daniels SR, et al, for the American Heart Association Science Advisory and Coordinating Committee. AHA guidelines for primary prevention of cardiovascular disease and stroke: 2002 update:

- consensus panel guide to comprehensive risk reduction for adult patients without coronary or other atherosclerotic vascular diseases. *Circulation*. 2002;106:388–391.
9. Smith SC Jr, Blair SN, Bonow RO, et al. AHA/ACC guidelines for preventing heart attack and death in patients with atherosclerotic cardiovascular disease: 2001 update: a statement for healthcare professionals from the American Heart Association and the American College of Cardiology. *Circulation*. 2001;104:1577–1579.
 10. Brinkmann JR, Hoskins TA. Physical conditioning and altered self-concept in rehabilitated hemiplegic patients. *Phys Ther*. 1979;7:859–865.
 11. Duncan P, Richards L, Wallace D, et al. A randomized, controlled pilot study of a home-based exercise program for individuals with mild and moderate stroke. *Stroke*. 1998;29:2055–2060.
 12. Engardt M, Knutsson E, Jonsson M, et al. Dynamic muscle strength training in stroke patients: effects on knee extension torque, electromyographic activity, and motor function. *Arch Phys Med Rehabil*. 1995;76:419–425.
 13. Gordon NF, Contractor A, Leighton RF. Resistance training for hypertension and stroke patients. In: Graves JE, Franklin BA, eds. *Resistance Training for Health and Rehabilitation*. Champaign, Ill: Human Kinetics Publishers; 2001:237–251.
 14. Hesse S, Bertelt C, Jahnke MT, et al. Treadmill training with partial body weight support compared with physiotherapy in nonambulatory hemiparetic patients. *Stroke*. 1995;26:976–981.
 15. Macko RF, DeSouza CA, Tretter LD, et al. Treadmill aerobic exercise training reduces the energy expenditure and cardiovascular demands of hemiparetic gait in chronic stroke patients: a preliminary report. *Stroke*. 1997;28:326–330.
 16. Macko RF, Smith GV, Dobrovolsky CL, et al. Treadmill training improves fitness reserve in chronic stroke patients. *Arch Phys Med Rehabil*. 2001;82:879–884.
 17. Potempa K, Lopez M, Braun LT, et al. Physiological outcomes of aerobic exercise training in hemiparetic stroke patients. *Stroke*. 1995;26:101–105.
 18. Rimmer JH, Riley B, Creviston T, et al. Exercise training in a predominantly African-American group of stroke survivors. *Med Sci Sports Exerc*. 2000;32:1990–1996.
 19. Sharp SA, Brouwer BJ. Isokinetic strength training of the hemiparetic knee: effects on function and spasticity. *Arch Phys Med Rehabil*. 1997;78:1231–1236.
 20. Shepherd RB. Exercise and training to optimize functional motor performance in stroke: driving neural reorganization? *Neural Plast*. 2001;8:121–129. Review.
 21. Silver KH, Macko RF, Forrester LW, et al. Effects of aerobic treadmill training on gait velocity, cadence, and gait symmetry in chronic hemiparetic stroke: a preliminary report. *Neurorehabil Neural Repair*. 2000;14:65–71.
 22. Weiss A, Suzuki T, Bean J, et al. High intensity strength training improves strength and functional performance after stroke. *Am J Phys Med Rehabil*. 2000;79:369–376.
 23. Whittall J, McCombe Waller S, Silver KH, et al. Repetitive bilateral arm training with rhythmic auditory cueing improves motor function in chronic hemiparetic stroke. *Stroke*. 2000;31:2390–2395.
 24. Thompson PD, Buchner D, Pina I, et al. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity). *Circulation*. 2003;107:3109–3116.
 25. Lee CD, Blair SN. Cardiorespiratory fitness and stroke mortality in men. *Med Sci Sports Exerc*. 2002;34:592–595.
 26. Paffenbarger RS Jr, Hyde RT, Wing AL, et al. Physical activity, all-cause mortality, and longevity of college alumni. *N Engl J Med*. 1986;314:605–613.
 27. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273:402–407. Review.
 28. Sacco RL, Gan R, Boden-Albala B, et al. Leisure-time physical activity and ischemic stroke risk: the Northern Manhattan Stroke Study. *Stroke*. 1998;29:380–387.
 29. *Internal Classification of Functioning, Disability and Health, ICF*. Geneva, Switzerland: World Health Organization; 2001.
 30. Roth EJ, Heinemann AW, Lovell LL, et al. Impairment and disability: their relation during stroke rehabilitation. *Arch Phys Med Rehabil*. 1998;79:329–335.
 31. Roth EJ. Natural history of recovery and influence of comorbid conditions on stroke outcome. In: Gorelick P, ed. *Atlas of Cerebrovascular Disease*. Philadelphia, Pa: Current Medicine; 1994:22.1–22.15.
 32. Roth EJ, Harvey RL. Rehabilitation of stroke syndromes. In: Braddom RL, ed. *Physical Medicine and Rehabilitation*. 2nd ed. Philadelphia, Pa: WB Saunders; 2000:1117–1163.
 33. Gresham GE, Duncan PW, Stason WB, et al. *Post-Stroke Rehabilitation*. Clinical Practice Guideline, No. 16. Rockville, Md: US Department of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research. AHCPR publication No. 95-0662; May 1995.
 34. Duncan P. Synthesis of intervention trials to improve motor recovery following stroke. *Top Stroke Rehabil*. 1997;3:1–20.
 35. Waters RL, Yakura JS. The energy expenditure of normal and pathologic gait. *Crit Rev Phys Rehabil Med*. 1989;1:183–209.
 36. Olney SJ, Griffin MP, Monga TN, et al. Work and power in gait of stroke patients. *Arch Phys Med Rehabil*. 1991;72:309–314.
 37. Bjuro T, Fugl-Meyer AR, Grimby G, et al. Ergonomic studies of standardized domestic work in patients with neuromuscular handicap. *Scand J Rehabil Med*. 1975;7:106–113.
 38. Roth EJ, Mueller K, Green D. Stroke rehabilitation outcome: impact of coronary artery disease. *Stroke*. 1988;19:42–47.
 39. Roth EJ, Green D. Cardiac complications during inpatient stroke rehabilitation. *Top Stroke Rehabil*. 1996;3:86–92.
 40. Roth EJ. Heart disease in patients with stroke, II: impact and implications for rehabilitation. *Arch Phys Med Rehabil*. 1994;75:94–101.
 41. Gresham GE, Phillips TF, Wolf PA, et al. Epidemiologic profile of long-term stroke disability: the Framingham Study. *Arch Phys Med Rehabil*. 1979;60:487–491.
 42. Sacco RL, Benjamin EJ, Broderick JP, et al. American Heart Association Prevention Conference, IV: prevention and rehabilitation of stroke: risk factors. *Stroke*. 1997;28:1507–1517.
 43. Sacco RL, Wolf PA, Kannel WB, et al. Survival and recurrence following stroke: the Framingham Study. *Stroke*. 1982;13:290–295.
 44. Smith GV, Silver KHC, Goldberg AP, et al. “Task-oriented” exercise improves hamstring strength and spastic reflexes in chronic stroke patients. *Stroke*. 1999;30:2112–2118.
 45. Visintin M, Barbeau H, Korner-Bitensky N, et al. A new approach to retrain gait in stroke patients through body weight support and treadmill stimulation. *Stroke*. 1998;29:1122–1128.
 46. Mol VJ, Baker CA. Activity intolerance in the geriatric stroke patient. *Rehabil Nurs*. 1991;16:337–343.
 47. Convertino VA. Effect of orthostatic stress on exercise performance after bed rest: relation to in-hospital rehabilitation. *J Cardiac Rehabil*. 1983;3:660–663.
 48. Franklin BA, Sanders W. Reducing the risk of heart disease and stroke. *Physician Sports Med*. 2000;28:19–26.
 49. Hambrecht R, Wolf A, Gielen S, et al. Effect of exercise on coronary endothelial function in patients with coronary artery disease. *N Engl J Med*. 2000;342:454–460.
 50. Franklin BA, Kahn JK. Delayed progression or regression of coronary atherosclerosis with intensive risk factor modification: effects of diet, drugs, and exercise. *Sports Med*. 1996;22:306–320. Review.
 51. Monga TN, Deforge DA, Williams J, et al. Cardiovascular responses to acute exercise in patients with cerebrovascular accidents. *Arch Phys Med Rehabil*. 1988;69:937–940.
 52. King ML, Guarracini M, Lenihan L, et al. Adaptive exercise testing for patients with hemiparesis. *J Cardiopulm Rehabil*. 1989;9:237–242.
 53. Hoskins TA. Physiologic responses to known exercise loads in hemiparetic patients. *Arch Phys Med Rehabil*. 1975;56:544. Abstract.
 54. Moldover JR, Daum MC, Downey JA. Cardiac stress testing of hemiparetic patients with a supine bicycle ergometer: preliminary study. *Arch Phys Med Rehabil*. 1984;65:470–473.
 55. Bachynski-Cole M, Cumming GR. The cardiovascular fitness of disabled patients attending occupational therapy. *Occup Ther J Res*. 1985;5:233–242.
 56. Fletcher BJ, Dunbar SB, Felner JM, et al. Exercise testing and training in physically disabled men with clinical evidence of coronary artery disease. *Am J Cardiol*. 1994;73:170–174.
 57. NIH Consensus Development Panel on Physical Activity and Cardiovascular Health. Physical activity and cardiovascular health. *JAMA*. 1996;276:241–246. Review.
 58. Surgeon General of the Public Health Service. Surgeon General’s Report on Physical Activity and Health (S/N 017-023-00196-5); 1996. Available at: <http://www.fitness.gov/execsum.htm>. Accessed March 24, 2004.

59. American College of Sports Medicine Position Stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc.* 1998;30:992-1008.
60. Bohannon RW, Walsh S. Nature, reliability, and predictive value of muscle performance measures in patients with hemiparesis following stroke. *Arch Phys Med Rehabil.* 1992;73:721-725.
61. Hamrin E, Eklund G, Hillgren A, et al. Muscle strength and balance in post-stroke patients. *Ups J Med Sci.* 1982;87:11-26.
62. Roth EJ, Mueller M, Green D. Cardiovascular response to physical therapy in stroke rehabilitation. *Neuro Rehabil.* 1992;2:7-13.
63. MacKay-Lyons MJ, Makrides L. Cardiovascular stress during a contemporary stroke rehabilitation program: is the intensity adequate to induce a training effect? *Arch Phys Med Rehabil.* 2002;83:1378-1383.
64. Hjeltnes N. Capacity for physical work and training after spinal injuries and strokes. *Scand J Soc Med Suppl.* 1982;29:245-251.
65. Thompson PD, Funk EJ, Carleton RA, et al. Incidence of death during jogging in Rhode Island from 1975 through 1980. *JAMA.* 1982;247:2535-2538.
66. Siscovick DS, Weiss NS, Fletcher RH, et al. The incidence of primary cardiac arrest during vigorous exercise. *N Engl J Med.* 1984;311:874-877.
67. American College of Sports Medicine. *Guidelines for Exercise Testing and Prescription.* 6th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2000.
68. Kohl HW III, Powell KE, Gordon NF, et al. Physical activity, physical fitness, and sudden cardiac death. *Epidemiol Rev.* 1992;14:37-58. Review.
69. Thompson PD, Klocke FJ, Levine BD, et al. 26th Bethesda conference: recommendations for determining eligibility for competition in athletes with cardiovascular abnormalities: Task Force 5: coronary artery disease. *Med Sci Sports Exerc.* 1994;26(suppl):S271-S275.
70. Adams RJ, Chimowitz MI, Alpert JS, et al. Coronary risk evaluation in patients with transient ischemic attack and ischemic stroke: a scientific statement for healthcare professionals from the Stroke Council and the Council on Clinical Cardiology of the American Heart Association/American Stroke Association. *Circulation.* 2003;108:1278-1290.
71. Fletcher GF, Balady GJ, Amsterdam EA, et al. Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. *Circulation.* 2001;104:1694-1740.
72. Bruce RA. Comparative prevalence of segment S-T depression after maximal exercise in healthy men in Seattle and Taipei. In: Simonsen E, ed. *Physical Activity and the Heart.* Springfield, Ill: Charles C Thomas; 1967.
73. Palmer-McLean K, Harbst KB. Stroke and brain injury. In: Durstine JL, Moore GE, eds. *ACSM's Exercise Management for Persons With Chronic Diseases and Disabilities.* 2nd ed. Champaign, Ill: Human Kinetics; 2003:238-246.
74. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc.* 1982;14:377-381.
75. Pollock ML, Franklin BA, Balady GJ, et al. Resistance exercise in individuals with and without cardiovascular disease: benefits, rationale, safety, and prescription: an advisory from the Committee on Exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association. *Circulation.* 2000;101:828-833.
76. Barker E. *Neuroscience Nursing: A Spectrum of Care.* St. Louis, Mo: Mosby; 2002:626.
77. Fletcher BJ, Griffin PA, Rice CR, et al. Cardiovascular disease. In: Fletcher GF, Banja JD, Jann BB, et al, eds. *Rehabilitation Medicine: Contemporary Clinical Perspectives.* Philadelphia, Pa: Lea & Febiger; 1992:203-224.
78. Folstein M. Mini-mental status exam. *Int J Geriatr Psychiatry.* 1998;13:290-294.
79. Evans RL, Bishop DS, Matlock AL, et al. Family interaction and treatment adherence after stroke. *Arch Phys Med Rehabil.* 1987;68:513-517.
80. Tomlinson JL. Helping the family support the patient. In: Gillen G, Burkhardt A, eds. *Stroke Rehabilitation: A Function-Based Approach.* St. Louis, Mo: Mosby; 1998:512-518.
81. Duncan PW, Horner RD, Reker DM, et al. Adherence to postacute rehabilitation guidelines is associated with functional recovery in stroke. *Stroke.* 2002;33:167-177.
82. Gresham GE, Stason WB. Rehabilitation of the stroke survivor. In: Barnett HJM, Mohr JP, Stein BM, et al, eds. *Stroke: Pathophysiology, Diagnosis and Management.* 3rd ed. New York, NY: Churchill Livingstone; 1998:1389-1399.
83. Beck AT, Ward CH, Mendelson M, et al. An inventory for measuring depression. *Arch Gen Psychiatry.* 1961;4:53-63.
84. Radloff L, Teri L. The use of the Center for Epidemiological Studies depression scale with older adults. *Clin Gerontol.* 1986;5:119-137.
85. Yesavage JA, Brink TL, Rose TL, et al. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res.* 1983;17:37-49.
86. Hamilton M. A rating scale for depression. *J Neurol Neurosurg Psychiatry.* 1960;23:56-62.
87. Glader EL, Stegmayr B, Asplund K. Poststroke fatigue: a 2-year follow-up study of stroke patients in Sweden. *Stroke.* 2001;33:1327-1333.
88. Angeleri F, Angeleri VA, Foschi N, et al. The influence of depression, social activity, and family stress on functional outcome after stroke. *Stroke.* 1993;24:1478-1483.
89. Cooper R, Cutler J, Desvigne-Nickens P, et al. Trends and disparities in coronary disease, stroke, and other cardiovascular diseases in the United States: findings of the National Conference on Cardiovascular Disease Prevention. *Circulation.* 2000;102:3137-3147.
90. Joseph LN, Babikian VL, Allen NC, et al. Risk factor modification in stroke prevention: the experience of a stroke clinic. *Stroke.* 1999;30:16-20.
91. Gordon NF, Salmon RD, Mitchell BS, et al. Innovative approaches to comprehensive cardiovascular disease risk reduction in clinical and community-based settings. *Curr Atheroscler Rep.* 2001;3:498-506.
92. Ades PA, Waldmann ML, McCann WJ, et al. Predictors of cardiac rehabilitation participation in older coronary patients. *Arch Intern Med.* 1992;152:1033-1035.
93. Greenlund KJ, Giles WH, Keenan NL, et al. Physician advice, patient actions, and health-related quality of life in secondary prevention of stroke through diet and exercise. *Stroke.* 2002;33:565-571.
94. Gordon NF. Hypertension. In: Durstine JL, Moore GE, eds. *ACSM's Exercise Management for Persons With Chronic Diseases and Disabilities.* Champaign, Ill: Human Kinetics; 2003:76-80.
95. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness and flexibility in healthy adults. *Med Sci Sports Exerc.* 1998;30:975-991.
96. American Association of Cardiovascular and Pulmonary Rehabilitation. *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs.* Champaign, Ill: Human Kinetics; 2004.

KEY WORDS: AHA Scientific Statement ■ stroke ■ exercise ■ rehabilitation ■ physical activity ■ risk