FOCUSED REVIEW

Benefits of Exercise for Community-Dwelling Older Adults

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This focused review highlights the benefits of exercise and physical activity for community-dwelling older adults. It is part of the study guide on geriatric rehabilitation in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. This article specifically focuses on the benefits of physical activity and exercise for older adults with regard to morbidity, mortality, and disability. It discusses the appropriate preexercise screening and evaluation procedures for older adults contemplating exercise. Last, it reviews the current literature on the benefits of varying modes of exercise to modify the most prevalent chronic medical conditions of late life, including arthritis, heart disease, diabetes, stroke, pulmonary disease, and osteoporosis.

Overall Article Objective: To summarize the current knowledge regarding the therapeutic benefits of exercise for community-dwelling older adults.

Key Words: Aging; Chronic disease; Exercise therapy; Rehabilitation.

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PERHAPS THE MOST SIGNIFICANT change impacting health care in the 21st century is the growth of the median age of the population. A decline in fertility and a 20-year increase in the average life span during the second half of the 20th century have resulted in significant changes not just in the American population but also in the world population.[1] Improvements in life expectancy have produced consequences. The growing number of adults age 65 years or older places large demands on the public health system and on medical and social services.[2] Chronic diseases that commonly affect older adults contribute to disability, diminish quality of life (QOL), and increase the costs of basic health care and long-term care. The US Center for Disease Control and Prevention has emphasized the importance of addressing the growing burden of disability and chronic illness, especially as it pertains to the cost of health care.[2]

Although many of the recent advancements in medical care derive from merging advanced technology with scientific methods, perhaps the most universal and effective treatment for chronic illness and disability in late life is physical exercise. Reductions in physical activity are associated with significant impairments and limitations in function, augmenting disablement and chronic illness. Exercise can reduce morbidity, reverse physiologic impairments, ameliorate functional loss, and are an important means of both preventing and treating chronic disease. Exercise therapy is a fundamental aspect of rehabilitation, providing rehabilitation professionals with the opportunity to play an important role in meeting these public health challenges. The purpose of this review is to aid rehabilitation clinicians in this task.

OUTCOMES INFLUENCED BY EXERCISE

To discuss the benefits of exercise for older adults, it is important to understand the varied rehabilitation outcomes that exercise can influence. These include medical outcomes, such as morbidity and mortality, disablement outcomes, such as function and disability, and psychobehavioral outcomes, including self-efficacy and QOL. In this review, we focus primarily on medical and disablement outcomes but mention psychobehavioral outcomes when pertinent. Although medical outcomes are generally well understood as representing morbidity, the burden of disease, and mortality, disablement outcomes are often confused. This confusion likely arises from differences in terminology between the disablement concepts of Nagi[3] and the first and second versions of the World Health Organization's *International Classification of Impairments, Disabilities and Handicaps*.[4,5] In the present review, we follow the terminology advocated by Jette,[4] who makes these definitions: (1) impairments, dysfunction or abnormalities in body systems; (2) functional limitations, restrictions in basic physical actions; and (3) disability, difficulties in doing activities of daily living (ADLs).

CHANGES ASSOCIATED WITH AGING

Much of the original research on exercise interventions in older adults was directed at reversing age-associated physiologic impairments such as reduced aerobic capacity[6,7] and muscle weakness.[8,9] This approach was based on the recognition that physiologic changes associated with aging were very similar to those seen with physical inactivity and that are, in many cases, reversible with exercise. Most rehabilitation professionals are familiar with the common physiologic changes associated with bedrest and aging. Common changes include worsening cardiovascular status including reductions in aerobic endurance, changes in body composition, bone loss and skeletal muscle atrophy, and weakness. In contrast, exercise can improve maximal and submaximal aerobic capacity, augment maximal cardiac output, reduce resting blood pressure, and produce favorable changes in body, bone, and muscle composition. Beyond age-associated physiologic declines and independent of disease burden, changes in function and disability have long been recognized for their association with aging.[10-12] It is estimated that 32% of community-dwelling adults 70 years or older have difficulties in physical functioning and 20% have difficulty in performing at least 1 ADL.[13] Importantly, a more recent review[14] of US trends in functioning and disability among older adults suggests that rates of functional limitations and disability are declining. The causes of these changes over the past decade have yet to be sufficiently identified. Nevertheless, this report[14] is important for various reasons. First, it shows that the commonly held assumption that functional limitation and disability are normal consequences of aging is
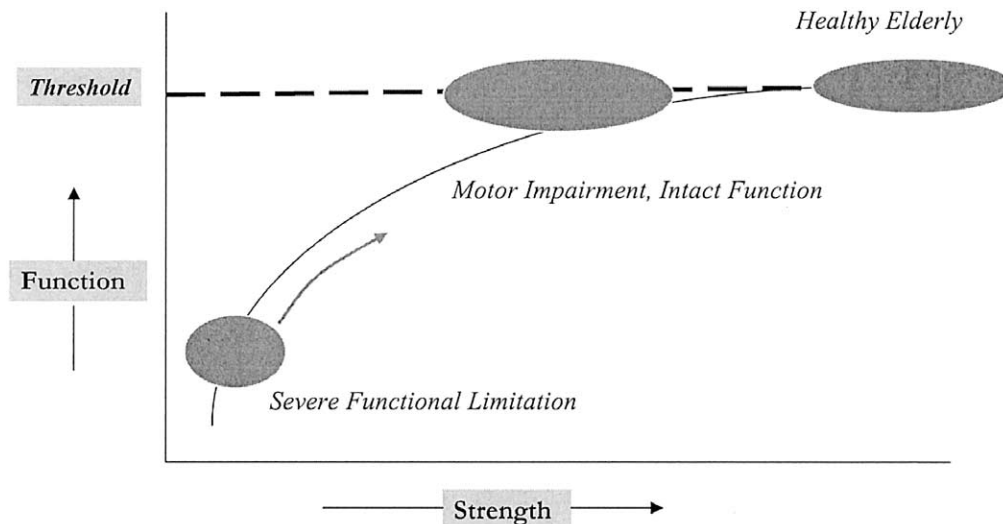
Fig 1. The curvilinear relationship between impairments (ie, reduced strength) and function shows that, at low levels, small increases in strength lead to large increases in function. In contrast, for people at or above the functional threshold (Healthy Elderly), strength improvements have diminishing effects on function; nevertheless; these improvements add to strength reserves, thus augmenting one's resistance to functional decline.

not true. Second, these findings impact greatly on projections of future health costs and public health initiatives. Interestingly, changes in overall physical activity during this time (the past decade) do not appreciably account for the apparent postponement of functional loss and disability.[15]

PHYSICAL ACTIVITY'S RELATION TO MORTALITY, MORBIDITY, AND DISABILITY

Physical activity and fitness are directly linked to improvements in mortality, morbidity, and disability. From an epidemiologic perspective, the benefits of exercise are often characterized by measuring physical activity or physical fitness. Physical activity represents an optional behavior, and physical fitness represents an achieved condition resulting from increased physical activity. Both are well acknowledged for impacting positively on mortality.[16,17] A graded, inverse relationship between total physical activity and mortality has been identified.[17] Physical activity initiated in late life continues to improve mortality, having a strong effect on longevity, even when accounting for factors such as smoking, hypertension, family history, and weight gain.[18] Further, high levels of physical activity and physical fitness lessen morbidity. Many studies have shown benefits for patients with conditions as varied as cardiovascular disease (CVD), respiratory disease, dementia, and cancer.[19-23] More recent work has shown that physical activity may also offset disability. Analysis of the more than 10,000 older adults participating in the Established Populations for Epidemiologic Studies of the Elderly showed an almost 2-fold increased likelihood of dying without disability among those most physically active compared with those who were sedentary.[24] Over the past decade, recognition of these varied benefits has led to several national consensus statements emphasizing the importance of physical activity in late life, including statements provided by the National Institutes of Health[25] (NIH), the American College of Sports Medicine[26] (ACSM), and the US Surgeon General's office.[27]

EFFECTS OF VARIOUS EXERCISE MODES

Initial exercise research was predicated on the assumption that improvements in physiologic impairments would lead to enhanced functional performance and amelioration of disability. Therefore, early studies that used forms of endurance training or resistance training evaluated physiologic outcomes.

They showed improvements with regard to endurance, aerobic power, balance, strength, muscle cross-sectional area, and fiber-type distribution. As studies expanded to evaluate functional outcomes, inconsistencies arose, with improvements in physiologic outcomes not always leading to functional enhancements. These inconsistencies were associated with several factors. First, endurance exercise without any component of resistance training has a weak influence on function. Endurance exercise, most commonly evaluated in the form of walking or bicycling, has strong effects on cardiovascular impairments, leading to improvements in morbidity and mortality. With regard to function, however, studies have shown, at best, limited improvements.[28] Second, the relation between impairments and function is nonlinear.[29-31] As shown in figure 1, and originally described by Buchner and de Lateur,[29] a threshold exists after which enhancements in an impairment, such as strength, will no longer add to continued improvements in function. This helps explain why augmentation of strength could produce dramatic improvements in function among frail nursing home residents[32] and, at the same time, produce minimal effects on the function of healthy elders.[29] Above the functional threshold, additional impairment reduction may add to reserves of strength, augmenting one's resistance to functional decline.

Based on these concepts, progressive resistance training (PRT) has generally been best accepted as the optimal means of enhancing and maintaining function in older adults. These recommendations are supported not only by the many intervention studies performed in both community-dwelling and institutionalized elders[33-35] but also by reports that show the positive association between impaired strength and functional performance.[31,36-38] More recently, impairments in muscle power have gained attention.[39] Muscle power, which is the product of force and velocity, is a related but different attribute from muscle strength, which is the ability to exert force. Muscle power declines more precipitously in late life than muscle strength.[40] Across a large variety of important mobility tasks, the associations between muscle power and function are consistently larger than the associations between muscle strength and function.[41,42] Muscle power can be improved in older adults. In contrast to PRT, exercise with a high-velocity training component can enhance power.[43,44] Resistance training designed to enhance muscle power enhances function,[45] but, to

date, direct comparisons between this approach and PRT have only been conducted within pilot studies.[46]

In contrast to many of the previously mentioned studies featuring resistance training via exercise machines or free weights, other recent investigations have examined use of exercises that are very similar to the target functional tasks. These studies build on the well-established concept of specificity of training. In sports, specificity refers to the concept that optimal training will occur when an athlete's training exercise is very similar to the task for which he/she is training. If the "sport" for which older adults are training is functional independence, then it would make sense to design exercises that are rich in functional specificity. Reports[47-51] in both institutionalized and community-dwelling older adults have shown functional improvements after participants performed exercises that were similar to bed mobility, transfers, and general mobility tasks. Direct comparisons between specificity-rich exercises and more classical forms of resistance training still need to be completed.

The possibility that exercise could be an effective means of ameliorating or improving disability (ie, ADL performance) is less clear. Among the most functionally compromised older adults, such as those in nursing homes, exercise has an ameliorative effect on disability. In contrast, in an important review addressing community-dwelling older adults, Keysor and Jette[52] noted that, although many exercise studies have shown improvements in impairments and function, relatively few have shown improvements in disability. This disparity is confusing partly because measures of function directly predict disability among healthy elders as well as disabled ones.[53] This discrepancy likely reflects several factors. First, many studies were not adequately designed for the purpose of evaluating disability: they had insensitive disability measures and insufficient sample sizes. Second, some studies may have featured exercise interventions that had insufficient intensity to produce the desired changes. Last, disability is influenced other factors, including those related to the adult's beliefs, behaviors, and environment.[4] It may be that the optimal exercise intervention must address all 3 issues.

SCREENING OLDER ADULTS FOR EXERCISE

It is well accepted that all older adults, regardless of their underlying medical conditions, should receive a medical screening before they begin an exercise program.[26,54-57] Screening examinations should serve a number of purposes, including (1) screening individuals for safety in performing exercise, (2) identifying medical problems that would require modification of the exercise prescription, and (3) identifying impairments and limitations that the exercise program will target.

In discussing the safety concerns in exercising, it is helpful to consider the risks of cardiac events and sudden death. Surprisingly, insufficient data exist regarding the risk of adverse cardiac events in older adults initiating exercise. The risk for sudden death during exercise decreases with increased age.[54] Estimates of cardiac events, such as myocardial infarction, suggest that the small increases in risk associated with even vigorous exercise (ie, >6 metabolic equivalents, eg, climbing hills or doubles tennis) would be attenuated by the benefits of exercise training and that increases in physical activity and exercise would over time reduce that risk.[55] The adverse effects of a sedentary lifestyle are also well understood. A sedentary lifestyle adversely affects every major body system,[33] and it contributes to the functional decline associated with all of the most prevalent chronic conditions of older age. Therefore, as has been previously suggested, perhaps the approach to the elderly patient contemplating exercise should not

Table 1: Contraindications to Participation in an Exercise Program

Unstable angina or severe left main coronary disease
End-stage congestive heart failure
Severe valvular heart disease
Malignant or unstable arrhythmias
Elevated resting blood pressure (systolic, >200mmHg; diastolic, >110mmHg)
Large or expanding aortic aneurysm
Known cerebral aneurysm or recent intracranial bleed
Uncontrolled or end-stage systemic disease
Acute retinal hemorrhage or recent ophthalmologic surgery
Acute or unstable musculoskeletal injury
Severe dementia or behavioral disturbance

start with the question "Is this patient safe to exercise?" but, rather, "Is this patient safe to be sedentary?"[58] Nevertheless, contraindications to exercise exist (table 1). They include conditions that reflect unstable or severe heart disease, severe vascular pathology (eg, aortic aneurysm), uncontrolled or end-stage systemic conditions, severe dementia or behavioral disturbance, and recent ophthalmologic concerns.[55,57,58]

The medical history and physical examination should address pertinent body systems (table 2). The history should include screening questions addressing cognitive impairments, depression, stroke, cardiopulmonary function, hydration status, endocrine disease (eg, diabetes mellitus, hypothyroidism), retinal disease, peripheral vascular disease, hernias, hemorrhoids, stress incontinence, neurologic impairments, and musculoskeletal symptoms, including assessment for arthritis and osteoporosis. The physical examination should also be comprehensive. It should assess cognitive status, including orientation, attention, and short-term memory, and should also include carotid artery auscultation, auscultation of heart and lungs, abdominal examination including inspection for hernias, palpation of the aorta and auscultation for bruits, evaluation of peripheral pulses, screening neuromusculoskeletal examination, and assessment of balance and mobility skills.

The history and physical examination findings that would herald further evaluation and treatment before the older adult begins an exercise program include delirium, previously undiagnosed heart murmur (especially if consistent with aortic stenosis), resting tachycardia, resting bradycardia (especially if not drug induced), orthostatic hypotension, undiagnosed vascular murmur, undiagnosed bruit (carotid or abdominal), pericardial rub, enlarged aorta, and symptomatic or undiagnosed hernia. Additional diagnostic tests should include a resting electrocardiogram, to ensure that there are not new ischemic changes. According to both the ACSM[59] and the American Heart Association,[57] all older adults for whom moderate to vigorous exercise is considered require a screening exercise tolerance test. Controversy exists regarding these recommendations as they pertain to older adults, especially to persons 75 years or older.[55,60] This controversy is well articulated by Gill et al[55] who have stated that the guidelines are not applicable to older persons and, even if they were, could not be implemented reliably. It is beyond the scope of the present review to discuss their concerns in detail. However, based on the information to date, it would be reasonable for older persons having no overt cardiac disease to be monitored for signs and symptoms of cardiovascular abnormalities only during the initial stages of an exercise program; one would then consider further evaluation only if the person was symptomatic (eg, angina, decrease in systolic blood pressure [SBP] ≥20mmHg, increase in SBP to

Table 2: Components of the Screening History and Physical Examination of an Older Adult Wanting to Initiate an Exercise Program

History and Physical Examination	Comments
Screen for cognitive deficits (executive function, memory, concentration)	Indicates ability to participate independently vs need for supervision
Screen for symptoms of depression	May influence participation and can be benefited by exercise
Assess hydration status (orthostatic hypotension)	New onset or poorly managed symptoms should be addressed prior to participation
Cardiac symptoms or findings (valvular heart disease, eg, aortic stenosis, angina, or arrhythmias)	New onset or poorly managed symptoms should be addressed prior to participation
Pulmonary symptoms or findings (CHF, asthma)	New onset or poorly managed symptoms should be addressed prior to participation
Vascular disease	
PVD	PVD symptoms may be targeted for treatment
AAA	AAA may be contraindication to exercise, especially resistance training
History or symptoms of endocrine disease (diabetes, hypothyroidism)	New onset or poorly managed symptoms should be addressed before participation
History of retinal disease	Potential risk for hemorrhage if acute or poorly managed, although under appropriate conditions exercise will enhance retinal perfusion
History of hemorrhoids, hernias, or stress incontinence	All can be worsened with the Valsalva maneuver if exercise is conducted inappropriately
Neurologic disease (stroke or transient ischemic attack)	New onset or poorly managed symptoms should be addressed before participation
Musculoskeletal disease (ie, severe arthritis, osteoporosis, joint deformity or instability)	Acute or poorly managed symptoms should be addressed before participation
Mobility and balance skills	Will influence design and goals of exercise program

Abbreviations: AAA, abdominal aortic aneurysm; CHF, congestive heart failure; PVD, peripheral vascular disease.

≥250mmHg or diastolic blood pressure [DBP] to ≥120mmHg, or repeated increases in heart rate to ≥90% of age-predicted maximum).

Supervision or modification of the exercise program may be necessary under a variety of circumstances. Patients with cognitive impairments, such as mild dementia, may benefit from supervision to optimize safety and compliance. Patients with stable conditions that could be exacerbated by the Valsalva maneuver, such as hernias, hemorrhoids, or stress incontinence, may benefit from initial supervision, to ensure that they are performing resistance exercises correctly. Patients with diabetes mellitus, postural hypotension, or stable cardiac or pulmonary disease may require supervision and clinical monitoring to ensure they are appropriately managing their condition, given the changes in physical activity. Additionally, for older persons with cardiovascular concerns, resistance training, as opposed to endurance training, may be the initially chosen mode of exercise: consensus is growing that resistance training may actually reduce the risk for cardiovascular events in comparison to aerobic exercise.[35,58,61] Musculoskeletal impairments associated with contracture, joint instability, or inflammation will likely require directed treatment before initiation or modification during an ongoing exercise program. The exercise program itself should target the specific impairments and limitations identified, providing the underlying chronic diseases are appropriately medically managed.

PREVALENCE OF CHRONIC DISEASES

Although the causes of functional loss and disability among older adults are commonly multifactorial, certain chronic diseases are the most prevalent contributors. The 5 most common chronic illnesses among older adults are arthritis, CVD, diabetes, respiratory disease, and stroke.[62,63] Specifically, arthritis affects over 60% of women and 50% of men 70 years or older.[62] CVD, including hypertension and heart disease, is present in 40% and 31% of all women and men aged at or over the age of 65 years, respectively. Diabetes mellitus, respiratory disease, and stroke are also very prevalent, more so among men than women, affecting over 10% of people 75 years or older.[63] All 5 of these illnesses are recognized as leading causes for disability, hospitalization, and death in older adults.[2,63] An additional condition that is very prevalent among older adults is osteoporosis. Both osteoporosis and osteopenia increase dramatically after age 65, with osteoporosis being more than 3 times more prevalent among persons at or over 85 years as compared with those between 65 and 74 years.[2] Exercise can play an important role in the primary and secondary prevention and management of each of these conditions.[58] References for each topic and our summarized recommendations are presented in table 3.

Osteoarthritis

Osteoarthritis (OA) is the most prevalent chronic condition of older adults, affecting over half of all adults over age 65. Traditionally, recommendations for older adults in the management of OA included refraining from many types of physical exercise for various reasons. Concerns were that exercise could increase pain, advance joint destruction, and lead to injuries.[64] As evidenced in recent consensus statements by both the NIH and the American Geriatrics Society, exercise is an effective treatment in the primary, secondary, and tertiary prevention of OA and its consequences.[64,65] Reports show that reductions in aerobic capacity, because of inactivity in these patients, have been corrected effectively through walking programs,[66,67] use of a stationary bike,[68] or aquatic exercises.[66] Improvements in strength can be achieved through low- and high-intensity progressive resistance exercises, with greater improvements reported in studies using higher intensity training.[64,67,69,70] Interestingly, reductions in disability have been reported with group, individual, and home-based exercise pro-

Table 3: Recommendations for Independent Exercise, by Medical Condition

Conditions	Recommendation
Osteoarthritis,[56,64] cardiovascular disease,[80,134] diabetes[92]*	PRT 　2–3 times weekly at 13–17 on the Borg Scale 　2–3 sets of 8–10 repetitions 　Greater strength gains will be achieved at higher Borg Scale ratings Aerobic training 　Examples: walking, biking, aquatic exercise 　2–3 times weekly 　Progress up to 30–40min 　11–13 on the Borg Scale
Respiratory disease[94]	Train both upper and lower extremities separately at 60% exercise-tested maximal work capacity, which is roughly equivalent to 11–13 on the Borg Scale 　Upper-body exercises include arm ergometry, canoeing, swimming, low-resistance high-repetition weight lifting 　Lower-body exercises include walking, stationary bicycling, stair climbing 　Perform exercise 3–5 times weekly progressing to 30–60min/session 　Self-monitor dyspnea 　Increase intensity every 5th session as tolerated Theoretical benefits of PRT at higher intensities are yet to be shown
Stroke[103,109]	PRT 　2–3 times weekly at 13–17 on the Borg Scale 　2–3 sets of 8–10 repetitions 　Greater strength gains will be achieved at higher Borg Scale ratings Aerobic training 　Treadmill walking at normal gait speed or slightly faster 　More impaired subjects may benefit from supported treadmill walking 　2–3 times weekly 　Progress to 30–40min 　11–13 on the Borg Scale Task-specific training 　Perform functional tasks such as rising from chair, climbing stairs, squatting 　Progress to 2–3 sets of 8–10 repetitions
Osteoporosis[33,113,135]	PRT 　2–3 times weekly at 13–17 on the Borg Scale 　2–3 sets of 8–10 repetitions 　Note greater strength gains will be achieved at higher Borg Scale ratings 　Specific attention to spinal extensors is important Aerobic exercise 　Only strenuous aerobic exercise, including combinations of fast walking, stair climbing, jogging, or calisthenics have been shown to be beneficial
Falls, poor balance, and mobility problems[33,51,129,133]	PRT 　2–3 times weekly at 13–17 on the Borg Scale 　2–3 sets of 8–10 repetitions 　Note greater strength gains will be achieved at higher Borg Scale ratings Aerobic training 　Examples: walking, biking, aquatic exercise 　2–3 times weekly 　Progress to 30–40min 　11–13 on the Borg Scale Dynamic exercises 　Tai Chi 　High-velocity training: exercises with concentric component performed as quickly as possible to augment muscle power 　　Examples: repeated performance of leg exercises on exercise machines or common functional tasks such as chair rise or climbing a step.

NOTE. All recommendations assume that the patient has successfully passed appropriate screening and monitoring procedures to assess safety for independent exercise.
*For diabetes, follow strategies to avoid hyper- and hypoglycemia (see table 2).

grams, with no clear difference seen when modes of exercise are directly compared.[64,66,67,71] These results suggest that, in addition to correcting underlying physical impairments, involvement in exercise programs may alter individuals' beliefs regarding their own capabilities, therefore contributing to reductions in disability.[72] At present, the consensus is that exercise for patients with OA is safe; does not cause disease progression; and, rather than increasing pain, contributes to the

reduction of pain.[64,65] A recent report has suggested, however, that knee alignment and laxity may be an important factor to consider before initiating quadriceps strength training. Greater strength in this muscle group contributed to increased progression of radiographic changes among subjects with knee joint malalignment and laxity.[73] Randomized controlled trials (RCTs) are necessary to better evaluate the long-term effects of varying intensities of resistance training on disability and disease progression.

Cardiovascular Disease

CVD, characterized by hypertension, coronary heart disease, and/or congestive heart failure (CHF), represents the second most common chronic disease in older adults and the number 1 cause of death.[13] Of all the chronic diseases that affect older adults, it is perhaps CVD for which the benefit of exercise is most recognized. Nevertheless, there are still gaps in knowledge regarding how exercise therapy should be applied to older adults with these conditions.

Although hypertension is a leading cause of death in the United States for older adults, the literature contains little information specifically addressing the benefits of exercise for older adults with hypertension. This may, in part, be associated with the fact that the benefits of exercise on hypertension are age independent.[74] Reports generally address the physiologic effects of exercise on hypertension. A comprehensive meta-analysis in women and 2 comprehensive reviews showed that moderate intensity aerobic exercise, regardless of the exercise mode, can produce a 2% reduction in SBP ($\approx$11mmHg), produce a 1% reduction in DBP ($\approx$8mmHg), and reduce left ventricular hypertrophy in patients with more advanced hypertension. There is disagreement regarding the role of resistance training in the absence of aerobic training. However, a meta-analysis specifically addressing this topic suggested that improvements of 2% and 4% can be achieved for resting SBP and DBP, respectively.[74,75] Therefore, as suggested by Kokkinos et al,[74] we advocate for patients to undergo a combined exercise program that includes aerobic and resistance training.

Among patients with coronary heart disease, those 65 years and older account for more than half of all acute myocardial infarctions and coronary bypass operations in the United States.[76] As part of the Cochrane Database of Systematic Reviews, Jolliffe et al[77] conducted a systematic review of the effectiveness (on mortality) of exercise only and exercise in the context of a comprehensive cardiac rehabilitation program. By using meta-analysis, they reported that the exercise-only approach reduced total cardiac mortality by 31% and exercise plus cardiac rehabilitation reduced at 26%. Cardiac rehabilitation reduced cholesterol and low-density lipoproteins. It was not clear which form of intervention was superior, but analyses were limited, in part, because of an insufficient number of studies in women and older adults. In other recent reviews[76,78] specifically addressing the benefits of cardiac rehabilitation for the elderly, authors also cite the lack of a solid base of well-designed clinical studies defining the role of cardiac rehabilitation for elderly patients. Even so, studies show that both aerobic and resistance training can be beneficial in reducing cardiac risk factors, in correcting physiologic impairments caused by coronary heart disease, and in enhancing QOL. In coronary heart disease—although conclusions regarding the impact of exercise and disability cannot be made at this time— the results of a recently reported RCT[79] suggest that resistance training in physically disabled older women with coronary heart disease can enhance multiple domains of physical functioning. Despite the current evidence, appropriate referral of older adults with coronary heart disease to exercise programs

and cardiac rehabilitation is lacking. Future challenges include reducing these barriers as well as modifying the design and conduct of these programs to optimize participation and adherence.[76,78]

Most people suffering from CHF are age 70 or older, with a doubling of prevalence with each advancing decade, reaching a level of 7% to 10% in persons 80 years or older.[80] Once thought to be contraindicated, exercise studies conducted over the last decade have led to a number of recent consensus statements from national and international sources emphasizing the need for exercise training in the treatment of CHF.[80-83] Witham et al[80] stated, in their comprehensive review addressing the needs of older adults, that exercise improves CHF symptoms, maximal and submaximal exercise capacity, and many pathophysiologic mechanisms underlying CHF, including abnormalities of heart rate, skeletal muscle myopathy, cytokine expression, and ergoreceptor function. They added, however, that most studies have been conducted in younger, well-selected populations with CHF.[80] Despite the need for well-designed RCTs in older adults, it is universally recognized[80-83] that both aerobic and resistance training can be beneficial. Two studies of older CHF patients highlight this point. Pu et al[84] had older adults (mean age, 77y) perform 10 weeks of progressive resistance training at 80% single repetition maximal lift (1-RM). Pu showed improvements in muscle strength and endurance, increases in submaximal aerobic capacity, and cellular changes in skeletal muscle consistent with improved oxidative capacity. Improvements in peak oxygen consumption (Vo_2peak) were not seen with this form of training. Pu's study also showed that high-intensity resistance training could be conducted safely within this population. In a much larger study incorporating both gym- and home-based exercise, McKelvie et al[85] had subjects participate in 12 months of combined aerobic and resistance training. In these subjects with an age of 65 years and older, improvements were seen in Vo_2peak and muscle strength. Together these studies underscore that optimal aerobic and peripheral skeletal muscle effects are seen with a combination of aerobic and resistance training. Long-term effects on mortality and morbidity are not known at this time, but will, one hopes, be addressed through large, prospective, randomized trials currently underway in North America and Europe.[83]

Diabetes Mellitus

Diabetes mellitus (DM) is a major cause of mortality and morbidity among older adults. It is the sixth leading cause of death among adults 65 years and older and accounts for approximately 5.8 million US hospital discharges annually.[63] Exercise is now recognized as a critical component in the prevention and treatment of DM.[86] Although a number of studies have evaluated the effects of various forms of exercise on DM, interpretations of the data are challenging because of small sample sizes and varying results. Similar to hypertension, most studies have focused on physiologic outcomes. In-depth discussions of this topic can be reviewed elsewhere.[86,87]

Insulin sensitivity increases with aerobic exercise[86,87] and has been reported to increase with resistance training as well.[88] Perhaps the best conclusions regarding the benefits of exercise in older persons with diabetes can be derived from a meta-analysis by Boule et al.[89] They concluded that exercise training reduces glycosylated hemoglobin by an amount that should reduce the risk for diabetic complications. No significant changes in the body mass of subjects were seen when compared with controls. It is possible that the lack of changes in body mass may have been caused by a lack of sufficient studies evaluating high-intensity PRT. Also, only 3 of the 14 studies

Table 4: Strategies to Avoid Hypo- or Hyperglycemia During and After Exercise

Strategy	DM Type I	DM Type II
Adjustments to the insulin regimen	Take insulin at least 1h before exercise.	Hypoglycemia is rare, but if taking insulin or sulfonylurea, it is more likely. May need to reduce dose.
	If <1h before exercise, take insulin in nonexercising part of body.	
	Decrease dose of both short- and intermediate-acting insulin before exercise.	
	Alter daily insulin schedule.	
Meals and supplemental feedings	Eat a meal 1–3h before exercise and check to see if insulin is in safe range before exercise.	If taking insulin or sulfonylurea, may need supplemental feeding.
	Take carbohydrate snacks or beverage—at least every 30min if exercise is vigorous or long duration.	
Self-monitoring of blood glucose and urine ketones	Monitor blood glucose before, during, and after exercise to determine the need for and effect of changes in insulin dosage or feeding schedule.	Not required.
	Delay exercise if blood glucose is <100mg/dL or >250mg/dL and if ketones are present	
Determination of unique metabolic responses	Learn individual glucose responses to different types, intensities, and conditions of exercise.	Not required.
	Determine effects of exercise at different times of the day on blood glucose response.	

NOTE. From Horton ES. Diabetes mellitus. In: Frontera WR, editor. Exercise in rehabilitation medicine. 3rd ed. Champaign: Human Kinetics; 1999. p 221. Reprinted with permission.[92]

analyzed had subjects with a mean age over 60 years, again suggesting the need for more RCTs evaluating older adults. Of note, diabetic patients may reap many of the other cardiovascular benefits from exercise, such as improved lipid profile, blood pressure, and energy expenditure, that provide positive contributions to their overall health status and reduce the risk for CVD.[90-92] Because exercise can have immediate effects on circulating insulin and glucose, and because of the associated risks for hypo- or hyperglycemia, recommendations for type I and type II diabetic patients are presented in table 4.

Respiratory Disease

Chronic obstructive pulmonary disease (COPD), that is, bronchitis, emphysema, and asthma, affect 11% of older adults over age 70. Specifically, COPD is 1 of the 4 leading causes of death among older adults between the ages of 65 and 84 years, accounting for 6% to 7% of deaths in this age group.[13] As late as the 1970s, physicians were advising COPD patients that dyspnea was harmful and that patients needed rest, which contributed greatly to levels of deconditioning seen among patients suffering from COPD.[93] Despite the prevalence of chronic respiratory disease in older adults, a review of the literature reveals an absence of appropriate systematic reviews or meta-analyses of exercise interventions in older adults with COPD.[94] Most studies have focused on physiologic and functional outcomes, and it is only recently that disability has been appropriately evaluated as an outcome.

Given the pathophysiologic changes associated with COPD, the physiologic outcomes most commonly evaluated are those associated with aerobic capacity. Improvements in aerobic capacity with exercise can be achieved with both low- and high-intensity exercise.[93,94] In a direct comparison, however, Casaburi et al[95] showed that greater ventilatory benefits are seen with higher intensity training. Endurance can be enhanced in elders with COPD, with greater benefits seen with longer durations of participation,[96] which produces mitochondrial ox-

idative changes in skeletal muscle consistent with aerobic training in healthy elders.[97,98]

In addition to gaining these aerobic benefits, patients with COPD can improve their functional capacity through exercise. Physical function has been most commonly measured by the 6-minute walk test, with studies[99] showing improvement from lower-extremity training. Subjective dyspnea is another useful outcome measure because it is the primary symptomatic complaint of patients with COPD. Studies[93,94] have shown improvement in subjective dyspnea with both upper- and/or lower-extremity exercises. Interestingly, use of external sensory stimuli, such as music, in combination with exercise appears to augment the beneficial effects of exercise on dyspnea. The mechanism of these benefits is not known, but may suggest that, as is the case with arthritis pain, behavioral factors along with exercise may mediate improvements in functioning.[100]

In addition to the evidence above, a recent RCT by Berry et al[101] is notable for its finding of benefits to both functional and disability outcomes. The authors compared 3-month and 18-month combined upper- and lower-extremity exercise programs. Those subjects who exercised for the longer duration showed 6% improvements in 6-minute walk distances, 11% improvements in stair climb speed, and a 12% decline in disability. Beyond showing the superiority of long-term exercise in COPD, the Berry study is important in that it shows improvements in disability with exercise participation.

Although it is apparent that exercise can benefit patients with COPD, many unanswered questions still exist regarding the physiologic effects of exercise and the optimal mode of training for patients with COPD.

Stroke

A major cause of morbidity and mortality in the United States, strokes affect approximately 600,000 people annually, influencing 9% of all adults 70 years and older.[13] Although the

primary injury in stroke involves the upper motoneuron pathways of the brain, it is the impairments in musculoskeletal strength, limb range of motion, cardiovascular endurance, and functional performance that become the primary foci of rehabilitation treatment. A review of the literature reveals only 1 systematic review[102] and no consensus statements addressing the role of specific exercises in the rehabilitation of stroke. In a review on stroke rehabilitation and the role of exercise training, Shepherd[103] underscored several important points regarding exercise therapy in stroke care. First, many of the traditional individualized therapies for stroke are based on untested and unproven concepts. Second, evidence is growing that altered motor patterns and changes in muscle and connective tissue may be adaptive features because of weakness, spasticity, and disuse, as opposed to primarily resulting from neurologic injury. Last, therapies that focus on use and the performance of functional tasks may actually drive neurologic recovery. Because of the present review focuses on older adults living in the community, we do not address studies evaluating exercise therapies for acute stroke rehabilitation.

Recognizing the potential for functional decline after the completion of acute rehabilitation,[104] investigators have made postacute stroke patients the focus of a number of both RCTs and non-RCTs featuring conventional exercise therapy. Because hemiparesis and sedentary lifestyle after stroke contribute to reductions in endurance, cardiovascular exercise has been investigated. In an RCT of chronic stroke survivors participating in a 10-week exercise program, Potempa et al[105] reported that 30 minutes of exercise, 3 times per week, by using a modified cycle ergometer, produced improvements in $\dot{V}O_2$peak, workload, exercise time, and SBP at submaximal workloads. In a nonrandomized study of chronic stroke survivors, treadmill aerobic exercise training produced improvements in submaximal energy expenditure, directly reducing the cardiovascular demands of walking.[106] This study also highlighted the potential benefit of task-oriented training.

Studies using forms of strength and flexibility training have reported broader therapeutic benefits. In a study of African-American stroke survivors with a mean age of 53 years, but with approximately one third of participants over age 60, a 12-week exercise program produced improvements in $\dot{V}O_2$peak, strength, and flexibility.[107] Two other pilot studies[108,109] that assessed training in chronic stroke survivors have reported not only enhancement of strength but also improvements in function and decreases in self-reported disability when PRT was a major component of the training program. A study by Weiss et al[109] showed strength improvements in both the affected and unaffected sides of the body. In contrast to the clinical folklore that strength training would harm hemiparetic patients, these robust findings from studies of small sample size suggest that PRT may be an important mode of therapy.[103] Larger RCTs of PRT in stroke survivors are underway.

Other investigators have attempted to develop exercises that incorporate resistance training and emphasize specificity of training. By using methods similar to that described earlier for mobility-limited elders, Dean et al[110] reported an RCT of subjects who were 3 months or more poststroke (mean age, 62.3y). After participating in a 4-week circuit-training program of task-related exercises, participants showed improvements in functional performance, endurance, and force production of the paretic leg. Interestingly, it is becoming more broadly recognized that such specificity-rich exercise of the affected extremities may promote neurologic recovery; this phenomenon is the basis for ongoing research in both acute and chronic stroke survivors.[103,111]

OSTEOPOROSIS, FALLS, AND BALANCE

Exercise is an important component of treatment in the maintenance of bone mass and prevention of fractures in late life. Cross-sectional analyses have shown that adults who are physically active throughout life have a higher bone density than their sedentary counterparts.[112,113] In a study of postmenopausal women, comparing sedentary older women with age-matched controls who had run an average of more than 20 miles a week since menopause, Nelson et al[114] showed that, when normalized for body weight, the bone mineral density of the spine and radius were higher among the runners. Another study of older male athletes age 70 to 81 showed that weight-bearing exercise, regardless of type (endurance, resistance, or speed training), led to greater bone mineral content than that seen in age-matched sedentary controls. Even when the role of weight bearing is minimized, exercise that produces dynamic muscular forces of short duration and high frequency on bone will lead to greater bone density.[115,116] This fact is shown in part by a study[117] in active tennis players age 70 to 84, in whom bone mass was 4% to 33% greater within the dominant versus nondominant arms.

A wide variety of RCTs and non-RCTs have shown that exercise can assist in the maintenance of bone mass in late life.[115] A common conclusion from comprehensive literature reviews and from meta-analyses is that low impact, general exercise programs, such as walking alone, offer little protective effect, compared with strenuous aerobic exercise or resistance training.[115,118] Notable studies[119-122] incorporating strenuous aerobic exercise over 9 to 24 months found combinations of fast walking, stair climbing, jogging, and calisthenics augmented bone mass in study subjects as compared with controls. Generalized PRT conducted at high intensities ($\approx$60%–80% of 1-RM) increased bone mass in both men[123] and women.[124]

In a meta-analysis by Wolff et al[115] that reviewed both RCTs and non-RCTs in older adults, the overall treatment effect of exercise training was a reversal or prevention of bone loss of 0.9% per year. Data are insufficient to determine differences in overall treatment effects between resistance training and the other forms of exercise described above. The treatment effect is comparable to benefits seen in women with appropriate premenopausal calcium intake, leading some to minimize the potential benefits.[125] Because the absorption rate for bone per year occurs at approximately 1% per year, appropriate exercise could potentially negate the age-associated declines in bone density.

Maintaining or improving bone density is a focus in osteoporosis management because of the high association between bone density and the potential for fracture and associated morbidity and mortality.[116] Exercise can help modify other important factors such as muscle mass, strength, balance, and risk for falls. Along with improvements in bone density, Nelson et al[124] showed increases in muscle mass and strength with high-intensity PRT. Their research highlights the appropriateness of this form of exercise for older adults at risk for fracture.[33,124] Along with enhancements because of high-intensity PRT,[33,34] people at risk for falls have shown improvements with other forms of dynamic exercise, such as Tai Chi,[126,127] weighted vests,[128] and standing ankle exercises performed at high velocity.[129] Based on the existing RCTs, the estimated risk reduction in falls associated with exercise is between 29% and 49%.[126,130-133] Additionally, Campbell et al[130,131] reported that the risk for injurious falls was reduced by 37% with an exercise program that included strength, balance, and walking exercises. The superiority of any single mode of exercise in regard to balance enhancement or fall prevention has yet to be deter-

mined. Exercises that enhance combinations of force production, speed of movement, and balance would be rational. Finally, it should be emphasized that causes of falls are most commonly multifactorial and that the provision of an exercise program may partially address the varied factors contributing to falls and fractures.[133] Table 3 presents exercise recommendations based on the literature to date and also includes recommendations concerning the other common chronic illnesses confronting older adults discussed within the previous sections.

CONCLUSIONS

Exercise has therapeutic benefits for almost all community-dwelling older adults, especially those suffering from the most prevalent chronic illnesses. Its benefits include reductions in morbidity and mortality, and enhanced physiologic capacity, leading to improvements in overall functioning. Many questions have yet to be answered about the effects of exercise in ameliorating disability and the best mode, intensity, and duration of exercise for treating the most common chronic conditions of older age.

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