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GERIATRIC REHABILITATION

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Rehabilitation focuses on the functional outcomes of pathologic processes and uses a variety of therapeutic interventions to restore function. Geriatric rehabilitation differs from rehabilitation in younger persons in that many older patients suffer from multiple conditions that interact to produce disability. [1] Hence, an understanding of the disablement process is critical to rehabilitation of older persons. [2] This chapter reviews the current understanding of the way disability occurs, the use of rehabilitation to treat disability, and the gaps in research in this area.

METHODS

The basic search was conducted on the National Library of Medicine's PubMed database. The period covered was from 1980 through March 28, 2001. This search combined the terms *rehabilitation, recovery of function,* or *rehabilitation nursing* with terms for the following five conditions or topics: arthritis or arthroplasty; equilibrium, posture, gait, falls, or fractures; cerebrovascular disorders; exercise or physical fitness; and amputees. This search generated 5967 references.

The authors later added terms for physical therapy, occupational therapy, activities of daily living, self-help devices, and durable medical equipment. They also added a search on CINAHL (Cumulative Index to Nursing and Allied Health Literature), focusing on *wheelchair, walker, cane,* and *assistive technology.* Finally, in making the final selection for this project, they reviewed pertinent rehabilitation texts and their references, as well as references cited in some of the papers derived from the search.

THEORETICAL UNDERPINNINGS FOR GERIATRIC REHABILITATION

Rehabilitation is a comparatively new field of medicine, the development of which has occurred primarily because of successes in other areas of medicine. Historically, people did not survive acute illness, so rehabilitation was moot. Because coping with old age, chronic illness, and disability are relatively novel, rehabilitation does not have the long experience available to other areas of medicine. Thus, theoretical constructs for treatment of disability and rehabilitation are, comparatively speaking, less developed. For this reason, the field of rehabilitation is less ready for definitive randomized trials than are other areas of geriatric medicine. In many respects, rehabilitation research is analogous to can-

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cer research. The condition (disability or cancer) often is multicausal, with causal factors occurring over a lifetime, and multimodal treatment often is required. Successes in cancer research have occurred through a combination of epidemiologic research, followed by basic science research, followed by multiphasic human studies with considerable coordination among clinical care providers. Similar efforts are needed in rehabilitation, although currently the field lacks the cohesiveness seen in cancer research. The research priorities for rehabilitation recommended herein reflect the need for further epidemiologic and theoretical work.

Disability is a complex behavior with biologic causes (eg, deconditioning, age-related changes, illness), as well as social and economic causes. There are several theoretical frameworks for the causation of disability that tie together the traditional biomedical and biopsychosocial models of illness. The conceptual framework for disability most commonly used in rehabilitation medicine is the one adopted by the World Health Organization, which portrays the progression of disease to disability and handicap as a stepwise process. [3] Geriatric medicine in the United States more often uses a model originally espoused by Nagi and refined by Verbrugge, Jette, and others. [4,5] Recent revisions by the World Health Organization focus on the use of empowering terminology (eg, using the term *social participation* instead of *handicap*) and on the role of personal and environmental contextual factors. [6]

The ongoing empirical work testing these models is research of substantial importance to geriatrics in general and geriatric rehabilitation specifically. It is vital to the future of geriatric rehabilitation to determine how the trajectory of disability differs for different diseases and combinations of diseases. In addition, we need to better understand the extent and ways in which the disablement process is modified by social and environmental factors, as well as by aging per se and health care. Examples of applications to geriatric rehabilitation research are briefly reviewed herein.

One key question is whether disability represents the "final common pathway" or if the disablement process is unique for each person. The concept of the final common pathway is based on the premise that different diseases lead to common expressions of disability or frailty. [7] For example, lower-extremity impairment, upper-extremity impairment, visual or hearing impairment, and affective disorders all predict functional dependence—someone with three impairments has a 60% likelihood of developing disability in the next year, whereas the likelihood among persons with no impairments is 7%. [8] Data show that in many older adults there appears to be an orderly progression of disability, with self-care activities that are dependent on lower-extremity function (eg, mobility) being lost before those that are dependent on upper-extremity function (eg, self-feeding). [9] One consequence of the final common pathway thesis is the assumption that rehabilitation treatment could be directed to the disability irrespective of the underlying causal pathway. The clinical result might be screening for functional impairment via self-reported questionnaire with direct referral to physical therapy (PT) or occupational therapy (OT), and without evaluation by a physician to determine the reason why the patient has impaired function. Since many physicians have little training in evaluating the underlying causes of disability, [10] there is substantial appeal to this approach.

There is increasing evidence that disability does not necessarily progress in a uniform manner and that differences in the acquisition and progression of disability may be impor-

tant. Guralnik et al showed that stroke, hip fracture, and cancer, but not heart attack, are associated with the rapid development of severe mobility disability or "catastrophic disability." [11] They found that the incidence of catastrophic versus a more slowly progressive pattern of developing disability varies with age. People aged 85 or over with multiple medical conditions are more likely to have progressive rather than catastrophic disability. The pattern of disability acquisition, in turn, was found to be associated with mortality outcomes. For some conditions causing catastrophic disability, the timing of exercise or other rehabilitative interventions may be important. For example, there is some evidence that early surgery and early, intensive rehabilitation may improve outcomes after hip fracture over those seen with delayed surgery and rehabilitation. [12,13] In addition, there is evidence that diseases interact in unique ways. Some diseases appear to have multiplicative effects in producing disability; examples are the combination of osteoarthritis and heart disease, or hip fracture and cerebrovascular accident. [14]

A key factor both in the clinical treatment of patients and in planning a research agenda is remembering that the impact of disability at the individual and at societal levels must be distinguished. We readily appreciate that at the individual level some diseases are highly disabling (eg, spinal cord injury), but that other diseases are less disabling (eg, osteoarthritis). For example, in a representative sample of noninstitutionalized older Americans, a history of stroke was found to be associated with a twofold greater likelihood of disability and persons with arthritis were found to have a 1.5-fold greater likelihood of disability than do persons without these diseases. [15] In developing a research agenda, one wants to target the conditions of greatest importance both at the individual level and at the societal level. Societal impact is determined by the amount of disability produced by the condition in an individual and the prevalence of the disease in the population. Although there is substantial epidemiologic data on the prevalence and incidence of disability in the older population, [16] there is little information on the disabling impact of specific diseases at the societal level. A study by Verbrugge and Patrick illustrates the kind of information that is needed; they found that among men aged 70 or over, arthritis ranks as the number 1 cause of activity limitation, whereas cerebrovascular disease ranks as number 7. [17] This is because, as illustrated by the previously mentioned representative sample of noninstitutionalized older Americans, although arthritis produces less disability than stroke in any given individual, it occurs much more commonly than stroke (53% versus 5%). [15]

Better information on which diseases and conditions, alone and in combination, produce what kinds of disability could lead to the development of rehabilitative treatments that more precisely target the underlying mechanisms producing disability, thus improving the efficacy of rehabilitation. For example, exercise has been viewed as something of a panacea for functional deficits in the older population. However, a review by Keysor and Jette shows that relatively few exercise interventions have resulted in improved functional skills, even though improvements occur at the organ system level (eg, increased strength). [18] Keysor and Jette attribute these findings to an oversimplified theoretical rationale for exercise effects on severity of disability. They found that two of the five studies that showed improvement in functional outcomes targeted persons with chronic arthritis. Functional disability due to arthritis may respond better to exercise than do other causes of functional disability (eg, spinal stenosis).

A number of studies have shown that psychologic and social factors are associated with disability. These are particularly important factors for disability outcomes over time. For example, although correlations as high as 80% have been reported between measures of motor impairment and functional disability in persons recovering from acute spinal cord injury, [19] the correlations are lower among persons with chronic spinal cord injury. [20] Moreover, even though the extent and type of physical limitations bear a relationship to self-perceptions of disability, the relationship is not uniform. Only 70% of those reporting major mobility limitations and 80% of those using a wheelchair were found to perceive themselves as having a disability. [21] Increasingly, we are appreciating the influence of mental state on outcomes for a variety of diseases. Coexisting depression can adversely affect functional outcomes; stroke patients who are depressed, for example, have poorer functional outcomes. [22] Financial supports enable people to pay for personal assistance or equipment that in turn increases independence. Most insurance policies now cover the more basic types of adaptive equipment, but it can be difficult to obtain reimbursement for anything other than a standard wheelchair or commode. For instance, few insurance policies cover motorized scooters. Similarly, the physical environment is a key factor influencing functional outcomes among people with physical impairments. The Americans with Disabilities Act was enacted with this in mind. Someone who must use a wheelchair for mobility will be able to carry out activities in and outside the home only if the environment is wheelchair accessible. However, few studies have examined the role of these factors in the care of the older patient and how they may differ uniquely with age.

In addition, we need to understand the impact of disability from the perspective of the family and caregiver. The psychologic and financial burdens families face when patients survive with severe chronic disabilities are huge; these burdens are a source of significant anger at the health care system, and unmet needs may be common. [23,24] However, little is known about the effects of different types of caregiving on patients' outcomes from surgical and rehabilitation treatments. Some work suggests that, in the setting of chronic disease, training family and friends in methods of assisting patients and identifying family goals improves patient outcomes and prevents caregiver burnout. [25–28]

We need to understand better the ways people cope with disability over time (eg, avoiding the activity, using personal assistance, using assistive technology), the trade-offs between differing coping strategies, and if these vary for specific diseases and conditions. For example, is a wheelchair as beneficial for someone with the inability to walk because of cardiopulmonary disease as it is for someone who is unable to walk because of paraplegia or arthritis? Other key areas for further investigation include patient, family, and societal attitudes (eg, the influence of self-efficacy and sick-role perceptions on outcomes, induced disability with provision of personal assistance) and the costs and benefits of various types of assistive technology and enhanced environmental access (eg, the costs and benefits of using the principles of universal design both in the home and in public places, ie, deliberately designing products and environment to be usable by people of diverse abilities).

Giacomini discusses the merits and hazards of clinical research that attempts to draw on both qualitative and quantitative research traditions. [29] On one hand, she argues persuasively that qualitative findings may lose integrity when reduced and operationalized as quantitative variables. On the other hand, she points out that the two research traditions

address essentially different questions about the world, so their findings tend to complement rather than compete as contributions to knowledge. Rehabilitation research in particular needs to support the development of methodology to better adapt and incorporate work from these two traditional research approaches. Disability is the product of both social and physical (biomedical) phenomena; therefore, rehabilitation research must draw from methodology developed to study both.

Empirical data are needed to better elucidate the disablement process and its treatment, but conceptual and theoretical models are needed as well. Such models help to put existing data into context, establishing directions for future research and facilitating rigorous research methodology. To a substantial extent, rehabilitation research has been characterized by inadequate theorization, scientifically poor methodology, and inadequate descriptions of the studied services. [30,31] In a review of rehabilitation research, Johnston et al noted that most studies identify the inputs (ie, patient characteristics) and the outputs (eg, functional outcomes), but that what happened in rehabilitation usually is defined vaguely. [32]

Several researchers have attempted to provide theoretical models for differing aspects of rehabilitation. For example, Strasser and Falconer focused on the rehabilitation team, and Kramer examined the patient perspective. [33,34] Other investigators have tried to apply to rehabilitation research existing models for the disablement process and the health services research model of structure, process, and outcomes. [35–37] Hoenig et al applied the standard health services research framework of structure, process, and outcome to published stroke rehabilitation research in a comprehensive review of the literature to identify gaps in the research and then used their findings to develop and validate a model for the structure of rehabilitation care (Figure 1). [38,39] This model is used to organize sections of this chapter on the components of rehabilitation treatment. However, this work serves only as a beginning; considerable additional work is needed. Multiple studies will be needed over the next decade. Some elements of a rehabilitation taxonomy will apply across conditions and rehabilitation disciplines; other elements will need to be specific to the condition being treated. The development of a uniform terminology for use across all rehabilitation studies is essential for the progress of rehabilitation research.

Rehab 1 (Level B): **The first step required, in support of all other recommended research efforts, is to develop uniform terminology, so that multisite research consortia can be formed to allow faster progress, as was done in the field of cancer research over the past 50 years.**

Rehab 2 (Levels B, A): **Hypothesis-testing research is needed to determine the costs and benefits of treatment that is targeted generically at the disability versus treatment that addresses the underlying diseases and impairments.**

Rehab 3 (Level B): **If it is important to individualize treatment on the basis of underlying cause (see Rehab 2), then additional research will be needed to identify the most efficient diagnostic methods to distinguish among causes of disability, with an eye to identifying characteristics that may affect treatment planning and outcomes. For example, a sudden acute event may need condition-specific treatment, whereas a slow decline in function may be amenable to treatment at the level of disability.**

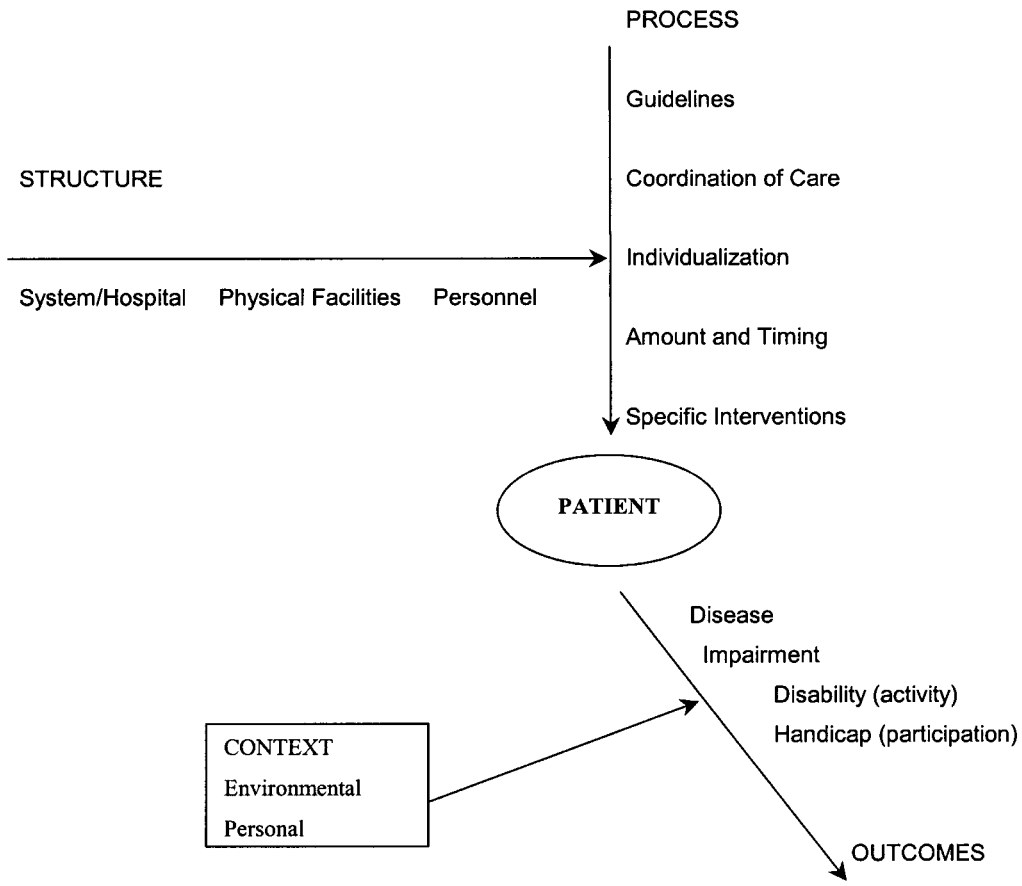

Figure 12.1—The structure, process, outcome rehabilitation model. (Based on Duncan PW, Hoenig H, Hamilton B, Samsa G. Characterizing medical rehabilitation interventions. In: Fuhrer MJ, ed.: Assessing Medical Rehabilitation Practices: The Promise of Outcomes Research. Baltimore: Brookes Publishing Co., 1997:307-17; and Hoenig H, Horner R, Duncan PW, et al. New horizons in stroke rehabilitation research. J Rehab Res Dev 1999; 36[1]:19-31.)

***Rehab 4 (Level B)*: Mechanistic studies are needed on the physiologic processes underlying geriatric disability and on the potential effect of the biology of aging on response to rehabilitation, particularly for sarcopenia and recovery from acute illness.**

***Rehab 5 (Levels B, A)*: Hypothesis-generating research followed by hypothesis-testing research is needed to better define the point in the disablement process when treatment is optimally instituted and whether or not optimal timing differs according to the disablement process (catastrophic versus progressive) or the underlying condition.**

***Rehab 6 (Level B)*: A longitudinal, nationally representative cohort study is needed to define the disabling impact of different diseases**

and conditions at the societal level, stratified by age group and major categories of interest to geriatrics (eg, nursing-home residents versus community dwellers). This information will allow better prioritization of research endeavors in geriatric rehabilitation.

Rehab 7 (Level B): **Observational and cohort studies are needed to identify the key social and environmental risk factors for current disability or progression into disability for the older patient, and the influence of these factors on rehabilitation outcomes.**

Rehab 8 (Level B): **Cross-sectional studies and longitudinal cohort studies of the relations between caregiving and outcomes are needed.**

Rehab 9 (Level B): **Adequate investigation of such factors as coping strategies, attitudes, and the cost versus the benefits of assistive technology and improved access will require both qualitative and quantitative research, and considerable work is needed to develop methods for combining the results of both these research traditions.**

Rehab 10 (Levels B, A): **Research is needed to articulate a clear theory or model of rehabilitation treatment that can then be tested.**

Rehab 11 (Level B): **Research is needed to delineate the components of the rehabilitation "black box" (eg, the dosage of rehabilitation).**

COMPONENTS OF REHABILITATION

STRUCTURE OF CARE

Settings

In 1997 the Commission on Accreditation of Rehabilitation Facilities defined three levels of inpatient medical rehabilitation (rehabilitation units in acute care or rehabilitation hospitals, and two levels of nursing-home rehabilitation), as well as outpatient and home health rehabilitation. [40] Although regulatory standards have changed since then, much of the research on the effect of various care settings on rehabilitation outcomes has been based on this traditional classification. The relationship of rehabilitation outcomes to setting for care has been most thoroughly studied for stroke rehabilitation, where better outcomes have been shown consistently for patients treated in specialized stroke units. [41] Similarly, treatment in geriatric evaluation units has been shown to improve outcomes over usual care. [42,43] What is unclear is why rehabilitation outcomes vary across settings. Since costs of care can vary markedly across settings, [44] this is a question of some interest. For example, Duncan et al showed that compliance with guidelines of the Agency for Health Care Policy and Research for stroke rehabilitation varies among postacute-care settings, and that better compliance is associated with better 6-month outcomes for stroke patients. [45]

Reimbursement has been and continues to be an important factor affecting the use of rehabilitation. [45–48] Reimbursement for rehabilitation is in flux, with the emergence and more recent decline of health maintenance organizations and the use of prospective payment for inpatient rehabilitation in the near future.

Providers

There are many different kinds of rehabilitation providers. Qualifications vary according to years of education (eg, master's degree for a physical therapist versus an associate degree for a PT assistant), training in unique therapeutic techniques (eg, occupational therapist versus physical therapist), and licensure (eg, unlicensed PT aide versus licensed PT assistant). In addition, state requirements for licensure and the privileges conferred with licensure vary considerably. In some states, physical therapists are allowed to treat patients without physician referral (open access); in others, physician referral is required. The effects of these regulatory differences are unknown. Though many third-party payers require physician referral irrespective of state regulations, such regulatory differences might have important effects on the utilization of PT, on the amount and kind of physician supervision provided to patients receiving PT, and on patient outcomes.

The differences in training among rehabilitation providers are believed to account for the distinct attributes of each type of provider; however, in reality very little is known about the relative merits of the different types of rehabilitation providers. Moreover, there can be considerable overlap in the services rendered by the different providers. The use of multiple different providers in rehabilitation is based on the belief that the resultant group interaction offers significant benefits to patients (eg, the combined treatment of functional mobility by OT, PT, and nursing may act to reinforce newly learned techniques). However, even though the comprehensive treatment team has been the foundation of rehabilitation, evidence of its effectiveness has been meager. [49] Indeed, we even lack data on how commonly multiple providers are involved in rehabilitative treatment. The use of a single type of provider may be common for the treatment of musculoskeletal disorders or postoperative care with orthopedic surgery, and the importance of team approach to successful rehabilitation of those conditions may be no more than a myth.

The benefits of a team approach have been studied for several conditions common in the older population, with inconclusive results for any of the conditions studied. For example, one meta-analysis of stroke studies did not show a significant difference in effect according to provider type (ie, PT versus OT). [50] Yet another meta-analysis showed that more successful stroke units are characterized by coordinated multidisciplinary rehabilitation, the use of education and training programs, and specialization of medical and surgical staff. [41] Among patients with rheumatoid arthritis, one randomized trial showed that team care predicts better overall health at 1 year than does usual care, as measured by the Sickness Impact Profile, but another randomized trial found just the opposite, with no differences between groups receiving team care and usual care. [51,52] With regard to geriatric rehabilitation specifically, Weiland et al examined Veterans Affairs geriatric units and found them to be a fairly diverse group, falling into two categories: standard (56% of geriatric units) and nonstandard (44% of geriatric units). Standard units were found to have better outcomes and, among other qualities, were characterized by the use of specifically assigned physicians, nurses, and social workers. [53]

The paucity of objective information about the benefits of using specific types of rehabilitation providers is remarkable in light of the high costs of rehabilitation and the potential for savings with the use of paraprofessionals. For example, in North Carolina salaries in 1994 for PT assistants ranged from $18,000 to $37,000, and salaries for physical therapists ranged from $34,000 to $80,000. [54]

Equipment

Most of the research data on rehabilitation equipment pertains to equipment used to provide physical modalities of one sort or another or for specific types of exercise (see the next section). However, studies of stroke rehabilitation show that the availability of rehabilitation equipment (eg, onsite apartment designed for use by people with physical disability) may be associated with better functional outcomes. [55,56]

PROCESS OF CARE: INTERVENTIONS

Interventions used in geriatric rehabilitation include exercise, adaptive techniques (modifications of the way an activity is performed), assistive technology (eg, canes, walkers, wheelchairs), physical modalities (eg, heat, cold, ultrasound), and orthotic (braces, splints) and prosthetic (artificial limbs) devices. [57] These are first briefly summarized, and then a more detailed review of the two most commonly used interventions, exercise and assistive technology, is provided.

Exercise programs are used to increase general flexibility, muscular strength, and aerobic endurance, but exercises may be used for more specific purposes (eg, preserving bone density, reducing joint pain, increasing coordination after a stroke). Different types of exercises have varying levels of data supporting their efficacy for specific conditions.

Adaptive techniques involve modifying a task so that it can be performed despite physical limitations. Adaptive techniques often are combined with assistive technology. The use of adaptive techniques and assistive technology enables the person to interact more favorably with the environment. For example, the use of a cane can make walking easier and safer. Although assistive devices can be purchased without the involvement of a rehabilitation provider, rehabilitation specialists often make recommendations about which devices will be most helpful in improving function and facilitating independence.

Physical modalities use physical processes to treat the patient; examples are ultrasound, diathermy, transcutaneous electrical nerve stimulation, whirlpool, massage, and the application of heat or cold. Research data on the efficacy of many physical modalities is limited. [58–60]

Orthotic devices are externally applied devices that act to support the musculoskeletal system. Examples are inserts or specially adapted shoes for arthritic problems of the feet, splinting and padding for overuse syndromes such as carpal tunnel syndrome, and braces to support an unstable or weak joint, such as an ankle-foot orthosis used after a stroke. Prosthetics are devices that act to substitute or replace a missing body part; examples are a prosthetic eye or prosthetic limb. Individual orthotic and prosthetic devices have been studied in some detail, but we need systematic research and a systematic review of the effectiveness of commonly used orthotics and prosthetics.

Benefits and Types of Exercise

There is substantial evidence that regular physical activity has a number of health benefits. For example, greater physical activity is associated with a twofold increase in the likelihood of dying without disability. [61] Given that physical activity is good, the question arises whether some kinds of physical activity are better than others. Each type of exercise appears to have unique benefits. Exercise can be classified in five categories: resistance, aerobic (endurance), balance, flexibility, and functionally based. Within each category

there are various subtypes, depending on how the exercise is delivered (eg, water based or weight bearing, isotonic or isokinetic), the rate at which the difficulty of the exercise is increased, and the frequency of exercise. This chapter provides an overview of the research on the use of the five categories of exercise to treat older patients but does not review research on the subtypes.

Resistance Exercise

Strength training has been a focus of considerable research in geriatrics. This is due, in part, to the strong evidence that muscle mass declines with age. [62,63] Work has been done to characterize the underlying physiology behind the change in muscle mass, but the cause of age-related decline in muscle mass, or *sarcopenia*, remains elusive. Factors that have been explored include loss of spinal alpha motor neurons causing denervation atrophy, loss of specific types of muscle fibers, increased vulnerability to contraction-induced muscle injury, incomplete tissue repair, disuse muscle atrophy, malnutrition, and reduced trophic factor release (eg, testosterone).

Much of the interest in resistive exercise has been generated because, not only are there age-related changes in muscle strength, but resistive exercise has been shown to improve a number of physiologic parameters of great importance to the older person, including insulin sensitivity, bone mineral density, aerobic capacity, and muscle strength. In addition, a variety of epidemiologic studies have related muscle strength to functional outcomes. For example, Gibbs et al showed that low baseline quadriceps strength predicts decline in walking speed 2 and 4 years later, [64] and others have shown that slower walking speed predicts dependence in self-care. [65] Thus, a logical chain of evidence in support of resistance exercise for the older population is apparent. Since muscle mass and function decline with aging, and resistance exercise can increase leg strength, and leg strength is associated with gait speed, and gait speed is associated with disability, many geriatricians have expected that resistance exercise would improve functional outcomes. Indeed, many basic activities of daily living (ADLs) are more dependent on gross motor strength than on aerobic capacity.

A review by Keysor and Jette showed that relatively few exercise interventions have improved functional skills, even though improvements occur at the organ system level (eg, increased strength). [18] The most consistent positive effects from exercise were found to be in strength, aerobic capacity, flexibility, and walking and standing balance, with over half of studies that examined these outcomes showing benefit. However, of the exercise studies that examined ADLs or overall disability, few showed benefit. For example, 14 of 21 studies that examined gait speed as an outcome showed a beneficial effect from exercise, but only 5 of 14 studies that examined ADLs showed a beneficial effect. A number of factors may account for these findings. It may be that functional benefits become apparent with greater improvements in strength. Investigators have examined combination interventions (eg, nutritional support plus resistive exercise), hoping to increase the benefits of resistance exercise in the older population, but none have shown added benefits over resistance exercise alone. [66,67] The lack of functional benefit from resistive exercise alone also may be because other factors besides muscle strength are determinants of functional performance. For example, leg strength explains only 25% to 30% of 6-minute walk distances. [68,69] Another factor that may account for the lack of functional benefit may be the specificity of exercise training; there is some evidence that the effect of resistive

exercise on muscle function may quite specific, [70,71] such that resistive exercise performed at one speed may improve performance at that speed but not at another speed. In turn, this might mean that function would be improved the most in those tasks performed at similar speeds to the exercise training itself. Studies are examining functionally based resistive exercise in the hope of helping patients generalize to specific functional tasks the gains in muscle strength achieved with resistive exercise (see below, the section on functionally based exercise).

Aerobic (Endurance) Exercise

Much of the research on aerobic exercise has focused on younger adults. Even so, there is a substantial body of research on the effects of aerobic exercise on the older adult. Most studies show that aerobic exercise can improve aerobic capacity. For example, Keysor and Jette report that 70% of studies of aerobic conditioning exercise in older adults showed improvements in aerobic capacity, but that the effect of aerobic exercise on body composition is less consistent. [18] Green and Crouse report in their meta-analysis that exercise training significantly improves maximum oxygen consumption in older people, with the magnitude being slightly less than that seen in younger people and inversely related to the individual's age. [72] Studies of aerobic exercise for specific conditions commonly seen in older adults have shown beneficial effects. For example, a meta-analysis showed that aerobic exercise significantly reduces systolic blood pressure in older adults. [73] Weight-bearing exercise for prevention of bone loss in postmenopausal women, walking for treatment of intermittent claudication, and exercise-based rehabilitation for coronary heart disease are additional examples. [74–76] However, it must be noted that a recent review of randomized trials of treatment for coronary heart disease found a bias toward younger adults, and few studies examined age-specific efficacy. [77] With regard to functional outcomes, a review found that longitudinal studies consistently show that long-term physical activity is related to postponement of disability in older adults, but that randomized trials of aerobic training do not necessarily support the results of longitudinal studies. [78] The reasons for this are unclear. However, much of the physiologic benefit of aerobic exercise is the prevention of or reduction in the severity of diseases whose end-organ effects cause disability (eg, stroke in uncontrolled hypertension), so older people who already suffer disability may experience less benefit.

Balance Exercise

Exercises can be designed to deliberately stress the systems involved in balance, including the musculoskeletal system and the vestibular system. When used to stress the vestibular system, these have been termed *habituation exercises*, and they appear to have efficacy in the treatment of benign positional vertigo. [79] Various types of exercise interventions, including Tai Chi, have been used to treat persons at risk for falls, with apparent benefit. [80–82] Balance exercise appears to be most effective when it is used as a part of a comprehensive or multifaceted approach; [83] the use of exercise to treat falls is discussed in detail (see the section on falls, below). Though we have made substantial progress in our understanding of balance exercise, its role in relation to other kinds of exercise needs additional study (see Rehab 18, below).

Flexibility Exercise

In a 1999 review of flexibility training, Krivickas pointed out that researchers have largely ignored flexibility training. [84] Most people, including professionals, believe that flexibility is beneficial; however, the belief is based on remarkably few data. Correlations have been observed between flexibility deficits and specific types of injuries, but all of these studies were in adolescents or young adults. Despite the fact that many disease processes common among elderly people can adversely affect flexibility (eg, stroke, arthritis), there are few studies in the older population of the effect on outcomes of a loss of range of motion or of the efficacy of exercise interventions to restore flexibility. One study found a relationship in older persons between decreased hip and ankle range of motion and a history of falls. [85] Another study compared flexibility exercise alone with flexibility exercise plus resistance training in older men and found that range of motion increases with the flexibility exercise alone but does not increase when resistance training is included, which suggests that resistance training may act to decrease flexibility. [86] With this exception, studies of flexibility have included the flexibility exercise as one component of a multifaceted exercise intervention. Research is needed to identify the unique contribution of flexibility exercise relative to other types of exercise (see Rehab 18, below).

Functionally Based Exercise

Functionally based exercises may be particularly beneficial for older persons. Functionally based exercise has been studied among disabled older patients in assisted-living centers and in demented patients in nursing homes, and as a type of stroke rehabilitation termed *massed activity* or *constraint therapy*. There is some evidence that the effects of exercise may be quite specific, with the greatest effect occurring with muscle function similar to that of the exercise itself. [70,71] This produces a dilemma, since a primary goal of exercise for the older person is to improve functional performance across diverse activities. The use of functionally based exercise may offer a solution to this problem.

Task-specific resistive exercise has been used successfully to improve the endurance during and rapidity of rising from sitting to standing by persons with mobility disability who live in congregate housing facilities. [87] Task-specific training involves training in tasks that are components of an act, for example, of rising from a supine to a sitting position on the side of the bed (which involves, first, rolling to one side, then moving the legs over the side of the bed, and finally pushing up to a seated position). As needed, partial assistance is provided or weights are added (eg, with a weighted vest) to ensure that task difficulty is sufficiently but not overly challenging.

In the nursing-home setting, functionally based exercises have been incorporated into daily routines. Examples include having the patient perform an extra sit-to-stand with each transfer or using graded steps that require the patient to independently perform an ever-increasing portion of ADLs. One of the benefits of functionally based exercises is that they appear to be effective even for demented patients. For example, in a randomized trial, Schnelle et al showed that an exercise program integrated into the daily nursing care of demented nursing-home patients results in improved endurance during ADLs. [88] However, this type of intervention appears to require increased nursing staff time. Rogers et al showed that patients undergoing skills training take, on average, twice as long to complete a given self-care task than do those in usual care. However, they require nearly 50% less physical assistance with self-care, and disruptive behavior declines by more than 50%. [89]

Recently Morris et al used a quasi-experimental design to compare the impact of nurses trained to elicit greater patient participation during daily care activities with a resistance and aerobic exercise program and with a control group. Both the exercise and the nursing rehabilitation groups were found to have better functional outcomes than the usual care group. However, the nursing rehabilitation group showed a trend (P = .07) for greater response than the exercise group. [90]

Massed activity (repetitive exercise activities for up to 8 hours per day), often used in conjunction with constraint therapy wherein the unaffected limb is constrained, is a new form of treatment for stroke patients that may have substantial efficacy for both acute and chronic stroke. [91] The activities include both functional activities and specific exercises to develop components of movement needed for functional activities. There is some evidence that this therapeutic approach may be effective not only for motor deficits but for aphasia as well. [92]

As with other types of exercise reviewed, a pressing need is to compare the efficacy of functionally based exercise with other types of exercise for various conditions and patient populations (see Rehab 18, below).

Comparisons of Types of Exercise

Few studies have compared the relative merits of differing forms of exercise for the same condition. Ettinger et al carried out a randomized trial of resistance exercise, aerobic exercise, and health education for knee osteoarthritis and found that they are both more effective than health education alone, but not significantly different from one another. [93] The study by Morris et al described in the preceding section was also a comparative study. [90] A meta-analysis of the Frailties and Injuries: Cooperative Studies of Intervention Techniques trials showed that the adjusted fall incidence ratio for treatment arms that included general exercise was 0.90 and for those that included balance was 0.83. [80] A somewhat different result may be seen in a study by Wolfson et al that showed that balance and strength training have different outcomes. [82] Specifically, their randomized study showed that balance training improves balance measures and strength training improves strength, and that there is no interaction between the two types of training.

Adaptive Techniques and Assistive Technology

Increasingly, assistive technology is being used to cope with disability. [94] In 1995, requests for durable medical equipment amounted to $6.27 million, 25.7% more than in 1994. [95] Although the majority of assistive device users are aged 65 or over, recent increases in the use of most devices far exceed the increase in population, even after accounting for age. From 1980 to 1994, the U.S. population increased by 19.1%; however, the age-adjusted use of leg braces increased by 52.1%, canes by 37.0%, walkers by 70.1%, and wheelchairs by 82.6%. [96] The increased popularity of assistive technology is due in part to the remarkable improvements in assistive technology design, both in functionality and in appearance. For example, design options for wheelchairs have exploded in the past two decades; wheelchairs are now lighter and many are motorized, and the ability to customize the wheelchair itself to the physical dimensions of the rider is improved. [97,98]

Despite the growing use of assistive technology, remarkably little information from research about its use in general and even less on its use by older persons is available. This lack is particularly striking when it is compared with the considerable body of work

in geriatrics on the use of formal and informal support, another commonly used method for coping with disability. Nonetheless, assistive technology offers great potential benefit for the older population. Epidemiologic data and one randomized trial show that assistive technology may decrease task difficulty, decrease hours of personal assistance, and decrease costs for institutional care. [99–101]

However, most studies of assistive technology have examined either the functionality of the equipment at a basic engineering level or technology utilization in general, examining overall use rather than use that is specific to the device or the activity. [102] Studies of assistive technology usage show that many disabled people lack potentially helpful devices, many of the devices that are provided are not used, and problems with device utility are common. [103–106] For example, one investigator found that up to half of the mobility aids owned by older persons are in disrepair or ill-fitting, and many devices are not used at all. [107] Some disuse may be due to improved health or changes in personal preferences. Two studies found that the primary reason cited by patients for discarding aids is improved health. [108,109] In addition, there appear to be gender differences in use of technology. [104] However, the provision process itself also appears to be a problem. For example, one study of older wheelchair users showed that they commonly obtain wheelchairs without professional assistance, but that those who do this are more likely to report problems with the wheelchair. [103] Problems with acquisition of assistive technology reported by O'Day and Corcoran include lack of funds to purchase the most suitable equipment, fraud and abuse by providers, and denials of needed equipment by third-party payers. [110] It is noteworthy that one study that examined an improved process for provision of bath aids reported that it resulted in higher device utilization and greater patient safety during bathing. [111] However, the functionality of wheelchairs in nursing homes, where more assistance might be available, is equally if not more filled with problems. [112] Key rehabilitation investigators are calling now for an investment in research to assess the outcomes of assistive technology. [113]

OUTCOMES OF CARE

Considerable work has been done on measuring functional outcomes in geriatric rehabilitation. Several excellent texts are available that review the current state of the field; one example is *Measuring Health* by McDowell and Newell. [114] Two major gaps persist in outcome measures: one concerns the most distal of functional outcomes, social participation (eg, community mobility) and quality of life, and the other concerns the use of outcome measures for specific types of interventions (eg, assistive technology) for specific conditions. Future research in all areas of rehabilitation will need to compare outcome measures across studies and across conditions, to allow attainment of consensus on which measures are most useful in what circumstances.

***Rehab 12 (Levels B, A)*: Hypothesis-generating research followed by hypothesis-testing research is needed to identify the critical factors responsible for the more optimal outcomes seen in some settings.**

***Rehab 13 (Levels B, A)*: Hypothesis-generating research followed by hypothesis-testing research is needed to examine the effect of changes in Medicare reimbursement on access to rehabilitation and the quality of rehabilitative care.**

Rehab 14 (Level A): **Randomized trials are needed to investigate the trade-offs of using less costly paraprofessionals to provide rehabilitation treatment, of using streamlined teams, and of using diverse strategies for team coordination and communication.**

Rehab 15 (Levels B, A): **Observational studies followed by randomized trials are needed to identify which conditions are best treated with a team approach (eg, disability resulting from multiple medical problems or a condition like stroke that causes multiple physical impairments) versus which conditions are treated equally well by a single provider (eg, disability due to a single condition causing a limited physical impairment, like osteoarthritis of the knee).**

Rehab 16 (Level A): **Randomized controlled trials are needed to examine whether specific kinds of resistive exercise, modes of exercise delivery, and combinations of treatments (eg, psychosocial intervention plus exercise intervention) might enhance functional outcomes for older persons, and which functional outcomes are affected to the greatest extent.**

Rehab 17 (Level A): **Randomized trials are needed on the health, functional, and quality-of-life benefits of aerobic exercise in older persons who are already disabled. The study population should be homogeneous with regard to amount and type of disability, and methodologic consideration should be given to how to deal with underlying medical conditions in the population and the differences they might produce in response to exercise. The outcome measures should be clearly specified; they might include physiologic parameters such as blood pressure, body composition, oxygen-carrying capacity, measures of physical function such as 6-minute walk distance, self-reported difficulty with activities of daily living, and measures of health-related quality of life like the Medical Outcomes Study 36-item Short Form 36 (SF 36).**

Rehab 18 (Levels B, A): **Hypothesis-generating research (eg, databases, cohort studies, case series) followed by hypothesis-testing research is needed to examine the benefits of differing types of exercise for specific conditions.**

Rehab 19 (Levels B, A): **Observational and cohort studies are greatly needed to identify effect size for key outcomes, which devices are promising enough to merit later comparative clinical trials, and what long-term follow-up shows among older people using assistive devices. These should be followed by randomized trials of the most promising devices.**

REHABILITATION FOR SPECIFIC CONDITIONS

There are important age-related differences in rehabilitation for nearly every condition treated with rehabilitation, primarily because of the high prevalence of multiple comorbid conditions in the older population and age-related changes in physiology of a variety of

organ systems that impact physical function. One study showed that medical comorbidity scores higher than 5 on the Cumulative Illness Rating Scale predicts greater length of stay and less gain in functional status, and 60% of geriatric patients receiving rehabilitation have scores of 6 or more. [115] Greater lengths of stay and lower functional outcomes have been reported for older patients for most conditions in which this has been examined. For example, among patients with spinal cord injury, it was found that length of stay is 58 days and the gain in score on the Functional Independence Measure is 27.8 among patients aged 60 and over, but the length of stay is 43 days and the gain on the Functional Independence Measure is 38.2 among patients aged 18 to 39. [116] Unfortunately, age-specific differences in outcomes have not been examined for all conditions treated with rehabilitation. For example, a National Institutes of Health consensus statement on rehabilitation of persons with traumatic brain injury states that little attention has been paid to the needs of high-risk age groups (eg, elderly persons), and it recommends research to examine the consequences and effects of rehabilitation after traumatic brain injury in elderly persons. [117] In addition, data are lacking on the disabling impact of specific medical conditions in the older population as a whole or for particular subsets (eg, nursing-home patients). Given the lack of empirical data to guide the selection of conditions to cover, the conditions reviewed herein were selected on the basis of prevalence in the older population along with likely utility and importance of rehabilitation to condition-specific outcomes. No doubt, important conditions are not included in this review.

ARTHRITIC AND RELATED MUSCULOSKELETAL PROBLEMS

Rehabilitation interventions are used widely to treat arthritic conditions. Research into their effectiveness is of great importance, and rehabilitation treatment of arthritic conditions is an active area of research. However, an important caveat in reviewing the literature and an important priority for research on rehabilitative treatment of arthritic conditions is to specify the underlying pathophysiology and the joint being studied. Otherwise, important findings may be overlooked. For example, two recent reviews of exercise for osteoarthritis showed conflicting results. Although differing methods may account for the discrepancies, another possibility is that the less conclusive analysis included studies of both the hip and the knee whereas the more conclusive study examined the knee alone. [59,118] From an anatomic point of view, it is likely that exercise is not as effective for a deep ball-and-socket joint like the hip as it is for a more mobile joint like the knee, where the muscles and tendons provide considerable support to the joint, and exercises that strengthen the muscles therefore are likely to affect the biomechanical function of the joint. Thus, a review that combines studies of the two joints might come up with inconclusive results, not because of the ineffectiveness of the intervention but rather because of the effectiveness differential.

Similarly, it might make sense at first glance to review painful musculoskeletal conditions of a given joint as a general group. However, there likely are important differences in response to therapy, depending on the underlying cause of the musculoskeletal disorder. Consider, for example, osteoporosis and osteoarthritis of the spine, with spinal stenosis as the specific example of the latter. Spinal stenosis is a consequence of bony hypertrophy and narrowing of the central neural canal. There is little reason to believe that exercise would reduce bony hypertrophy; if anything, just the opposite would result. Moreover, it is difficult to envision how alterations in the strength or mechanics of the paraspinous

muscles would affect the central canal. On the other hand, the underlying pathophysiology of osteoporosis likely would be affected beneficially by weight-bearing exercise; moreover, pain from the flexion deformities seen after compression fractures in spinal osteoporosis might well respond to flexibility and strengthening exercises for the paraspinous muscles. Indeed, one recent review of exercise for low back pain distinguished among major disease categories and found important differences in outcomes. [119]

A number of studies of exercise, assistive technology, and orthotics show that these can be effective strategies to reduce disability due to diverse musculoskeletal disorders, although the specific type and amount of exercise and the most useful devices and orthotics depend on the specific joints affected and the underlying disorder(s).

We lack comparisons of home-based versus clinic-based exercise for arthritic conditions. What is the difference in short- and long-term efficacy of exercise therapy for osteoarthritis of the knee from a one-time PT evaluation with recommendations for home exercise versus PT in the clinic three times weekly for 3 to 4 weeks? Does the amount and kind of patient education when prescribing a mobility aid affect outcomes? Which patients prescribed a cane would benefit from seeing a physical therapist for gait training, and which patients need no more assistance than that available from untrained staff at a local medical supply store?

STROKE

Post-stroke rehabilitation can be provided in a rehabilitation hospital, a subacute rehabilitation unit, a skilled nursing facility, or via home health or on an outpatient basis. Guidelines published in 1995 by the Agency for Health Care Policy and Research (renamed: Agency for Healthcare Research and Quality) as well as guidelines published in 2003 by the Veterans Health Administration suggest that choice of rehabilitation setting be dictated by the severity of the patient's impairment, the availability of family and social support, and the patient's or family's preferences [120,121] The research evidence on settings for stroke rehabilitation and use of massed activity to treat stroke-related deficits are discussed above, in the section on interventions.

Studies have shown surprising plasticity in the adult brain. [122] Currently, investigators are studying not only massed activity but also combinations of exercise and pharmacologic treatment (eg, sympathomimetics) in an attempt to enhance the responsiveness of the brain to interventions designed to facilitate motor recovery via neuronal plasticity. [123] This research has not targeted the older population per se, but since strokes are common in the older population, the work is pertinent to geriatric rehabilitation. Investigation into interventions to mold and enhance neural plasticity is a very exciting area of research in stroke rehabilitation, and work in this area that focuses on older persons will be needed.

A number of comorbid conditions can have important effects on stroke outcomes. Kelly-Hayes and Paige provide a review of psychosocial factors important to stroke recovery. [124] For example, depression is common after stroke and is associated with poor functional outcomes, and treatment of stroke-related depression may improve cognitive function post-stroke. [125,126] Stroke patients with dysphagia are at risk for malnutrition, which can adversely affect functional outcomes. [127] One study showed that early nutritional support in these patients reduces mortality. [128] Malnutrition may also adversely affect functional recovery by reducing endurance, interfering with rebuilding muscle strength, and increasing the risk of pressure ulcers and infectious complications.

CARDIAC DISEASE

The federal guidelines for cardiac rehabilitation note that elderly patients are referred for cardiac rehabilitation less frequently than younger persons, but that they likely would benefit from exercise-based cardiac rehabilitation. [129] However, there is little hard evidence of this because most cardiology clinical research has not specifically examined the older population. [77] In addition, the effect of comorbid cardiopulmonary disease on rehabilitation outcomes for other conditions needs further study in light of data suggesting that, for example, cardiac disease in combination with arthritis produces more disability that either condition alone. [11] We have good evidence that there are important age-related changes in cardiac function, [130] and cardiac disease is common in the older population.

HIP FRACTURE

The goals of hip fracture rehabilitation are to restore functional ambulation and independent self-care; however, many people have substantial decline in physical function after hip fracture despite surgery and rehabilitation. Several studies have shown that high-intensity postoperative PT may prevent postoperative complications and promote better functional outcomes. [13,131,132] However, a review suggests that definitive proof of the merits of early, high-intensity PT after acute hip fracture is lacking. [12] A prospective case series of nearly 600 patients aged 65 and over with hip fracture who were allowed full weight bearing showed that, after 1 year or more, 5.3% of those treated by internal fixation suffer loss of fixation or nonunion and 0.6% of those treated with hemiarthroplasty require revision. [133] However, a Cochrane Review concludes that there is insufficient evidence to determine the effects of early weight bearing after the internal fixation of an intracapsular proximal femoral fracture. [134] The merits of postoperative ambulation restrictions like “partial weight bearing” or “touch-down weight bearing” need further study, as older adults may have difficulty comprehending these instructions if they have cognitive deficits or postoperative delirium, and such restrictions in turn may interfere with optimal postoperative PT.

AMPUTATION

Amputation in older persons usually occurs in the setting of severe peripheral vascular disease, often in association with longstanding diabetes mellitus, sometimes complicated by hypertension or tobacco abuse. Comorbid disease, including cardiopulmonary disease, stroke, retinopathy, and prior amputation, are common and may affect the functional outcome (as does the level of amputation). Premorbid functional limitations and comorbid conditions must be considered both preoperatively in determining the level of amputation and the ability to tolerate repeated surgery, and postoperatively in determining the goals for rehabilitation. There are recent advances in design of artificial limbs that increase biomechanical efficiency, but at considerable financial cost. Andrews, as well as Cutson and Bongiorni, provide recent reviews of rehabilitation for the older amputee. [135,136] The cost-benefit trade-offs for older patients differ markedly from those seen with younger persons, for whom amputation usually is traumatic but the cardiovascular and musculoskeletal systems are otherwise intact.

DECONDITIONING, SARCOPENIA, AND FRAILTY

Deconditioning occurs with a decrease in activity level for whatever reason, and typically it includes loss of strength, loss of flexibility, and metabolic and hemodynamic abnormalities (eg, calcium wasting, orthostatic hypotension). [137] Deconditioning may occur with disuse because of pain, incoordination, or any other cause of decreased physical activity. A common cause of deconditioning is enforced immobility as a consequence of acute illness or hospitalization. Early mobilization during hospitalization and regular participation in exercise during hospitalization and after discharge are thought to be the most helpful interventions to prevent and treat deconditioning. However, evidence for the efficacy of exercise among acutely ill older patients is just beginning to appear. [138,139]

Deconditioning is thought to be one of the factors underlying the sarcopenia and frailty sometimes found with aging. Treatment of sarcopenia and related frailty is an active area of research in geriatrics. Research on deconditioning, sarcopenia, and frailty is highly pertinent to geriatric rehabilitation in that exercise, alone or in combination with other treatments (eg, growth hormone, nutritional support), is being used as a treatment for sarcopenia; moreover, deconditioning, sarcopenia, and frailty can adversely affect rehabilitation outcomes. The evidence on exercise interventions is reviewed in the intervention section of this chapter. However, some evidence supports the concept that sarcopenia is a complex condition due to the interaction of multiple factors, both hormonal and environmental. [140,141] The efficacy of rehabilitation treatment for sarcopenia likely will be enhanced as the complex physiologic abnormalities underlying this condition are better understood.

FALLS

"Falls" is a diagnosis not often mentioned in connection with rehabilitation, but rehabilitation interventions are among those often used to prevent falls. The most commonly used rehabilitation interventions in falls prevention programs are various types of exercise and home assessment with environmental modification. A review of randomized trials of falls prevention interventions identified 23 studies that included exercise, 9 studies of home assessment and surveillance, 1 study of hip protectors, and no studies of footwear. [142] The authors concluded that the majority of exercise studies suggest a decrease in falling, with balance training appearing to be the most effective exercise intervention, and they concluded that the majority of home assessment studies showed benefit as well. A Cochrane review of 18 falls prevention trials and one planned meta-analysis concludes that the evidence does not support the effect of exercise alone in establishing protection against falls, but that the evidence does support the use of exercise as one of multiple interventions specifically targeting identified risk factors in individual patients. [143] An editorial by Tinetti [144] identifies two research needs on falls: Research that focuses intently on single interventions (as opposed to the multifocal interventions previously tested) to better establish the potency of each intervention and to establish its utility for subgroups of patients, and research that would enable implementation in clinical practice of the results of this research. The American Geriatrics Society, the British Geriatrics Society, and the American Academy of Orthopaedic Surgeons recently issued a research agenda for falls and identified the following priorities: cost-effectiveness studies of falls-prevention strategies; examination of risk stratification to identify persons most at risk and persons who would

benefit the most; treatment interventions for specific subgroups of patients, including hospitalized patients and those with cognitive impairment; identification of the most effective elements of exercise programs (eg, types of exercise, duration, frequency); identification of patient groups most likely to benefit from home safety assessment; and examination of the merits of mobility aids for falls prevention. [145]

For further discussion of falls prevention, see Chapter 13 on cross-cutting issues.

PAIN

Acute, chronic, and acute-on-chronic pain problems are common in older patients. This is not surprising, given the prevalence of musculoskeletal problems and malignancies in this age group. Unfortunately, pain may be under-recognized in older patients, especially those with cognitive disorders. [146] Currently, the management of pain in older patients includes the use of medications, injections, exercise, physical modalities like heat or cold, behavioral approaches, assistive devices, and orthotics. [146,147] However, we know little about which interventions are most effective.

For further discussion of pain management, see Chapter 2, Geriatric Anesthesia.

Rehab 20 (Level B): **Epidemiologic and observational studies of older patients with specific disabling conditions are needed in order to identify risk factors and to select key outcomes for measurement in future clinical trials.**

Rehab 21 (Levels B, A): **Observational and cohort studies are needed to define the efficacy and safety of specific types of exercise, assistive devices, and orthotics for arthritic and musculoskeletal conditions. These studies could lead later to controlled trials comparing the most promising interventions.**

Rehab 22 (Levels B, A): **Observational and cohort studies are needed in the rehabilitation of musculoskeletal conditions to obtain preliminary data on the effects of the location of the physical therapy, the level of expertise of therapists needed, and how much is accomplished by education of elderly patients. This could lead eventually to controlled trials assessing these variables.**

Rehab 23 (Levels B, A): **Hypothesis-generating research followed by hypothesis-testing research is needed to identify the key components facilitating better outcomes that are seen in some settings and to identify ways to optimize treatment and outcomes among elderly patients unable to tolerate therapy in a stroke unit or rehabilitation hospital.**

Rehab 24 (Level A): **Randomized controlled trials of exercise-based cardiac rehabilitation, as a function of age and comorbid conditions, would be very valuable and are urgently needed.**

Rehab 25 (Level A): **Randomized controlled trials are needed to test the efficacy and safety for elderly patients of early, high-intensity physical therapy following hip fracture surgery and of postoperative restrictions on ambulation.**

Rehab 26 (Levels B, A): **Observational and cohort studies should be performed to compare the costs and benefits of using newer prostheses in younger and older persons; factors found to be associated with better outcomes for older persons should then be tested in controlled trials.**

Rehab 27 (Levels B, A): **Basic laboratory research is needed to determine the factors that cause sarcopenia or that interact to cause it in older persons. Findings from this research should then be used in clinical trials of interventions to prevent or treat sarcopenia.**

Rehab 28 (Level A): **Randomized trials are needed to examine the merits of specific falls-prevention interventions (eg, types or duration or frequency of exercise, mobility aids, home safety interventions) and for specific subgroups of elderly patients (eg, cognitively impaired, hospitalized) and to examine the cost-effectiveness of various falls-prevention strategies.**

Rehab 29 (Levels B, A): **Observational and cohort studies are needed to clarify the natural history of pain syndromes, identify risk factors, and describe the effects of treatment approaches. Ultimately, the most promising approaches should be identified and tested in controlled trials.**

KEY RESEARCH QUESTIONS IN GERIATRIC REHABILITATION

Rehab KQ1: **What is the process in elderly persons underlying the development of disability and the factors influencing the disablement process?**

Hypothesis-generating research: A nationally representative longitudinal study is needed to address two related research questions. First, what is the disability impact for older adults of specific diseases, both at the individual level and at the population level? For a variety of conditions, we have individual-level data on the amount of associated disability and population-level data on their incidence and prevalence, but we lack population-level data on the resultant disability. Second, how does the disablement process differ in older adults, what factors modify the disablement process, and do these vary across conditions? This latter investigation should examine the processes underlying catastrophic or acute-onset disability versus progressive disability. Existing longitudinal studies should be assessed to see if they could be adapted for these purposes. In addition, mechanistic studies are needed on the physiologic processes underlying geriatric disability and the potential effect of the biology of aging on response of older adults to rehabilitation.

Hypothesis-testing research pertinent to the disablement process in older adults is described under Rehab KQ2 and Rehab KQ3.

Rehab KQ2: **What are the costs and benefits of targeting treatment at differing aspects of the disablement process in elderly persons?**

Hypothesis-generating research: There is considerable diversity in the approaches used to treat common physical impairments and disabilities in the older population (eg, arthritic knee pain is treated with nonsteroidal medication, herbal preparations, injectable medications, narcotics, liniment, heat, canes, braces, exercise, and joint replacement). Observational studies are needed to identify current treatment patterns for various physical impairments and functional disabilities in the older population. The population(s) studied should be representative of disabled older persons, including nursing-home residents, persons with cognitive impairment, and community-dwelling older persons. Outcomes measured should include quality of care, costs, and function. Registries, administrative data, patient and provider surveys, and medical records could be used.

Hypothesis-testing research is needed to determine the costs and benefits of treatment targeted at the disability versus treatment targeted at the underlying disease or impairment. Rehabilitative interventions can be directed at the disability itself (eg, dependence on a wheelchair) or at underlying impairments (eg, muscle weakness). Evaluation to specify the underlying process can be time consuming and expensive, and some diagnostic tests have the potential for adverse effects. The merits of focusing on treatment of the disability may vary with the patient population and the underlying process. Randomized trials are needed, with careful definition of the populations and disabilities studied. Results of hypothesis-generating studies for both this key question and Rehab KQ1 should be used to identify the conditions and treatments to study.

Rehab KQ3: **What are the relative merits of diverse rehabilitative treatments targeted at similar aspects of the disablement process in elderly patients?**

Hypothesis-generating studies are needed to develop a taxonomy for rehabilitation structure and process of care. Considerable work in geriatrics and rehabilitation has been devoted to developing outcome measures. However, measures of the input side are lacking, which causes difficulty in determining how to best improve rehabilitation outcomes. Theoretical models to measure rehabilitation treatment need to be developed, followed by a uniform terminology, so that multisite research to allow faster progress can be conducted. Multiple research methods could be used to identify the key measures of rehabilitation care, including focus groups, medical record review, and observational studies. Hypothesis-generating studies are needed to develop new treatments for disability in the older population. Animal and preliminary human studies are recommended. Emerging treatments of potential utility for the older population include interventions to facilitate neuroregeneration and novel assistive technologies for mobility limitations, vision and hearing impairments, and behavioral disorders.

Hypothesis-testing research is needed to examine the merits of differing rehabilitation interventions for the same condition. The results of hypothesis-generating studies in Rehab KQ1, Rehab KQ2, and this key question should be used to help identify conditions and interventions to be studied. The condition and the interventions to be studied should be tightly

defined. For example, studies of musculoskeletal disorders should focus on a particular disease process (eg, tendinitis, fracture, osteoarthritis) and a particular joint (eg, shoulder, hip). Examples of interventions to be compared include differing methods of providing similar exercises (eg, exercise for rotator cuff tendonitis at home versus in clinic), types of exercise (eg, resistance versus functionally based exercise for cognitively impaired patients after acute hip fracture), or types of interventions (eg, cane versus exercise for osteoarthritis of the hip).

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