U.S. Department of Education

The Interagency Committee on Disability Research

Report to Congress on Physical Rehabilitation Research

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Prepared for:
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Prepared by:
CESSI

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Abbreviations

ADL	Activity of Daily Living
AHRQ	Agency for Healthcare Research and Quality
APTA	American Physical Therapy Association
CABG	Coronary Artery Bypass Graft
CDC	Centers for Disease Control and Prevention
CDRH	Center for Devices and Radiological Health
CPI	Clinical Practice Improvement
CRISP	Computer Retrieval of Information on Scientific Projects
FDA	U.S. Food and Drug Administration
HHS	U.S. Department of Health and Human Services
ICDR	Interagency Committee on Disability Research
ICF	International Classification of Functioning, Disability and Health
IOM	Institute of Medicine
NCCAM	National Center for Complementary and Alternative Medicine
NCMRR	National Center for Medical Rehabilitation Research
NHLBI	National Heart, Lung and Blood Institute
NIA	National Institute on Aging
NIAMS	National Institute of Arthritis and Musculoskeletal and Skin Diseases
NIBIB	National Institute for Biomedical Imaging and Bioengineering
NICHD	National Institute of Child Health & Human Development
NIDA	National Institute on Drug Abuse
NIDCR	National Institute of Dental and Craniofacial Research
NIDRR	National Institute on Disability and Rehabilitation Research
NIH	National Institutes of Health
NIMH	National Institute of Mental Health
NINDS	National Institute of Neurological Disorders and Stroke
NINR	National Institute of Nursing Research
NLM	National Library of Medicine
NRH	National Rehabilitation Hospital
NSF	National Science Foundation
NSF-BCS	National Science Foundation Behavioral and Cognitive Sciences
NSF-BES	National Science Foundation Division of Bioengineering and Environmental Systems
RCT	Randomized Controlled Trial
RMD	Rehabilitation Medicine Department
RRTC	Rehabilitation Research and Training Center
SBIR	Small Business Innovation Research
STTR	Small Business Technology Transfer
TKR	Total Knee Replacement
VA	U.S. Department of Veterans Affairs
VHA	Veterans Health Administration

Executive Summary

Physical rehabilitation services are essential to the functional status and independence of individuals with disabilities, particularly those with musculoskeletal conditions. These conditions affect millions of Americans and account for $45-54 billion in compensation costs and lost wages and productivity annually (Leopold 2004). Consider these facts:

- Physical disability far more often results from musculoskeletal conditions—arthritis, osteoporosis, broken bones, trauma caused by sports injuries or automobile accidents, back pain and cerebral palsy—than from neurological injury or disease.
- One in 10 people has difficulty walking, and that limitation is most commonly the result of musculoskeletal conditions.
- Knee osteoarthritis alone causes more mobility disability in the elderly than any other disease.
- The prevalence of people with disabilities due to musculoskeletal conditions will grow as we live longer.

Physical rehabilitation is used to treat all of these conditions; however, it encompasses much more than physical treatment. According to the Institute of Medicine (Brandt and Pope 1997), *rehabilitation* is:

> The process by which physical, sensory and mental capacities are restored or developed in (and for) people with disabling conditions—reversing what has been called the disabling process, and may therefore be called the enabling process. This is achieved not only through functional changes in the person (e.g., development of compensatory muscular strength, use of prosthetic limbs, and treatment of posttraumatic behavioral disturbances) but also through changes in the physical and social environments that surround them.

Physical rehabilitation research includes studying musculoskeletal function and performance, improving the capacity to perform specific activities, determining the role of the environment in fostering or reducing disability, and analyzing models of care delivery and their effects on disability.

Despite the significant impact of musculoskeletal disorders, the number of research projects supported by the federal government in physical rehabilitation for these conditions is small compared to the research effort in areas such as heart disease and cancer. Furthermore, there are few nationally accepted guidelines on physical rehabilitation therapies.

Congress acknowledged this gap in the federal research portfolio and directed the Interagency Committee on Disability Research (ICDR) in *Senate Report 108-345* "to report on the existing, agency-wide research activities relating to physical rehabilitation, opportunities for future physical rehabilitation research, and recommendations on how physical rehabilitation research

can be enhanced within the departments and agencies, including suggestions for those areas that need to be addressed through statutory changes."

This report presents the ICDR's response to the congressional directive. It includes the results of the survey of existing agencywide research activities related to physical rehabilitation. It also presents a summary of the current status of research in the field, a discussion of future research opportunities and general recommendations for enhancing physical rehabilitation research.

The reader will note a series of vignettes in the report, each located on a page preceding the introduction and each of the four sections. The vignettes are not intended to directly introduce the material in the subsequent sections. Rather, each presents a short story that attempts to put a human face on the problem of musculoskeletal disorders, and introduce some possible solutions. These vignettes were recommended for inclusion by the advisory committee closely involved in the development of this report. (Details about the committee can be found on p. 7).

Research Status: Physical Rehabilitation Literature

A literature review of published studies identified for this report revealed that while many of the studies addressed the issue of comparing broad categories of therapies, few addressed the more specific questions of therapy types, amounts, combinations and duration of effect, as well as potential improvements to existing therapies. The emphasis on comparing broad categories of therapy (such as exercise versus bed rest) was, however, a necessary first step toward eliminating nonuseful practices and refining effective ones. The review identified 14 randomized controlled trials (RCTs) and 19 systematic reviews that demonstrated the effectiveness of several types of physical rehabilitation therapies. For example, according to a systematic review of clinical trials, therapeutic exercises reduced pain and improved a person's ability to participate in daily activities such as eating and bathing, and exercise could improve aerobic capacity (Ottawa Panel 2005). According to a Cochrane Review, exercise is helpful to patients with chronic, low back pain (Hayden et al. 2005).

The use of rehabilitation services is perhaps the most understudied aspect of the perioperative management of total knee replacement patients (U.S. Department of Health and Human Services 2003).

This body of published evidence presents a base for understanding the effectiveness of current physical rehabilitation therapies. Researchers continue to add to this base through new studies and reviews. In addition, some researchers are beginning to study the effects of variations in timing or intensity of interventions. Current and future research efforts such as those funded by federal agencies will foster a greater understanding of the effects of combined treatments, multidisciplinary treatments and other factors influencing treatment outcomes.

Research Status: Current Federally Funded Projects

The primary federal agencies funding physical rehabilitation research are the:

- National Institutes of Health (NIH), including the National Institute of Child Health and Human Development (NICHD), the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), and the National Institute for Biomedical Imaging and Bioengineering (NIBIB);
- Veterans Health Administration's (VHA) Office of Rehabilitation Research and Development; and
- U.S. Department of Education's National Institute on Disability and Rehabilitation Research (NIDRR).

Federal agencies currently support physical rehabilitation research through individual research projects, larger research programs, training grants and small business grants. From agency reports, the ICDR identified a total of 191 currently funded individual research studies, 65 research programs, 34 research support grants, 31 small business grants, 12 training programs, nine conferences, five technology transfer grants, and two research networks. Supported research ranged from basic science to clinical practice research.

Currently funded research represents a continuing pipeline of studies: 58 of the 191 studies could have results that influence clinical practice within three years; 90 studies could see practical results within three–10 years; and 43 basic science studies cover topics that may lead to clinical innovations more than 10 years down the road. Although this appears to comprise a great deal of research activity, the total body of physical rehabilitation research is very small in terms of dollars and numbers of active studies when compared to research efforts for other major health conditions such as cancer or cardiovascular disease. For example, a search in Computer Retrieval of Information on Scientific Projects (CRISP) for currently funded grants (fiscal year 2006) using the search term *cancer* returned 9,572 results; a similar search using the term *cardiovascular* returned 3,342 results.

Opportunities for Future Research

Several factors must be taken into account when planning future research efforts. First, it is important to have an understanding of the amount and variety of the existing research, because research normally builds on previous efforts. This report provides such an overview. Second, it is necessary to consider the need for future research and the potential advancements in scientific methods to appreciate what is possible. Third, it is important to examine how to structure the overall research effort to most effectively advance the field.

The ICDR has identified demographics, care delivery, biomechanics, diagnoses, assessments, and interventions as areas in need of increased research funding. For example, the issues of healthy aging, diagnosis of disability, effective dosages (frequency, intensity, duration and timing) of interventions, and coping and self-efficacy were identified as critical research needs.

With respect to potential advancements in scientific methods, the National Center for Medical Rehabilitation Research (U.S. Department of Health and Human Services 2001) anticipates scientific advances relevant to physical rehabilitation including: tissue and cellular engineering; nanotechnology and materials science at the molecular level; biomechanical simulation and modeling techniques; computerized dynamic assessment of outcomes; and assistive technologies to improve independence and safety in self-care. In the next five to 10 years, these advances could affect the following areas: telehealth (the virtual home visit); intelligent garments; motion-induced therapies; the understanding of factors enhancing the adoption of new behaviors; robotic devices to replace scarce human resources; the synergy in combined treatments such as stem-cell therapy combined with exercise; and better timing of interventions.

With respect to intervention research and the improved ability to measure outcomes, the *National Institute on Disability and Rehabilitation Research Long-Range Plan for Fiscal Years 2005-2009* (U.S. Department of Education 2006) indicates that research is needed to support the development and evaluation of new interventions, products, devices and environmental adaptations (such as those needed for employment, community integration and independent living, and vocational rehabilitation) aimed at increasing the health status and functional abilities of people with a wide range of disabling conditions, including musculoskeletal conditions. Many of these new interventions will address the needs of people who are aging with a disability, with particular emphasis on minimizing secondary conditions. To aid in the evaluation of these new interventions, NIDRR will also fund research that will lead to the development of the next generation of valid and reliable measures of health and functional status among people with disabilities. These new measures would be applicable in a wide variety of clinical and community settings and would incorporate consumer perspectives to help determine the extent to which health status and functional capacity relate to an individual's ability to perform valued activities in his or her community. NIDRR will conduct research that identifies effective methods for translating data from these new outcome measures into information that can be used to inform decisions made by consumers, health insurance payers, provider organizations and clinicians.

An effective federal physical rehabilitation research agenda must consider a number of continuing challenges, such as:

- **An increase in disability rates** due to increasing elderly and sedentary populations, obesity rates and military or civilian injury rates;
- **A need for more financial resources** to support and promote existing and increased research capacities and funding for fellowships, improved research infrastructures and mechanisms for putting various technologies into practice;
- **A need for advanced tools to conduct studies,** including new instruments and techniques to study disability in the natural environment, and to improve outcome measures, especially those of patients' preferences and values;
- **A need for alternative study designs** when randomized controlled trials (RCTs) are not feasible, timely or ethical; and
- **The role of physical rehabilitation in clinical practice,** especially as part of programs for disease prevention and first-line treatments, either alone or in conjunction with pharmacotherapy. Initial rehabilitative therapy may reduce the

need for drug therapy and its associated costs and potentially harmful side effects.

Coordinating Federal Research and Meeting National Health Goals

Healthy People 2010, an ongoing campaign managed by the U.S. Department of Health and Human Services' (HHS) Office of Disease Prevention and Health Promotion, has set a series of goals for the U.S. population over the coming years. Two goals apply to musculoskeletal disorders: 1) preventing "illness and disability related to arthritis and other rheumatic conditions, osteoporosis and chronic back conditions;" and 2) "promoting the health of people with disabilities, preventing secondary conditions and eliminating disparities between people with and without disabilities in the U.S. population" (U.S. Department of Health and Human Services 2000). A well-executed research program in musculoskeletal disorders can significantly contribute to reaching these goals.

The ICDR has continued to foster coordination and collaboration between agencies, institutes and offices that are funding rehabilitation research. These agencies have been encouraged to review their mission statements to minimize funding overlap and maximize funding synergy among them. This coordination process is being fostered by regular reports from and discussions at ICDR meetings as well as through electronic communication among key decisionmakers. For example, extensive discussions among decisionmakers at NIDRR, the NIH, the VHA and the HHS' Office on Disability guided the development of the priorities on the basis of which NIDRRR recompeted the Spinal Cord Injury Model Systems grants. To further facilitate interagency coordination, the ICDR is developing a one-stop shop for information about federally sponsored rehabilitation research.

The ICDR and its member agencies are mindful of the complexities and budgetary challenges facing Congress in determining appropriation amounts for federally sponsored research. Recommendations for statutory changes to improve disability and rehabilitation research support in the federal government have been addressed in previous reports. One recommendation was to create a new agency for disability and rehabilitation research within the HHS (Brandt and Pope 1997); a second recommendation was to establish an independent institute or center within the NIH (Verville and DeLisa 2003).

These two recommendations, the results of a collaborative effort between the federal and private sector, took a comprehensive and broad view of the field of disability and rehabilitation research rather than a narrow focus on physical rehabilitation. In view of this, the ICDR draws the attention of the Congress to these existing recommendations.

The ICDR further wishes to draw the attention of Congress to the overwhelming proportion of medical and other costs to the U.S. economy due to chronic medical conditions in the United States. Individuals with limitations in their activities of daily living consume far more medical resources per capita than their nondisabled counterparts. Rehabilitation has the potential to not only return disabled individuals to their communities after a hospital stay or other acute care facility, but also to reduce their risk of secondary conditions and recurrent illnesses. To achieve this goal, much more basic and applied research in physical rehabilitation will be required.

Stretching to Ease Lower Back Pain

Four months ago, as I lifted a sheet of drywall, I felt a sharp, intense pain in my lower back. Anything strenuous, even just bending over, sent shooting pains down my spine. With no disability insurance, I was worried about how I would help support my family, including the new baby expected in seven months. My wife had already started putting in extra hours at work. Did I need to look for another line of work?

After the third week of back pain, my doctor referred me to a physical therapist, who showed me how to stretch and strengthen my hamstring muscles. Hamstring tightness limits motion in the pelvis in a way that increases stress across the lower back. I did a hamstring stretching exercise one to two times each day; after a couple of months, I could lift and bend at the construction site.

Today, for instance, I bent down to pick up one end of a beam that will help support the roof of a house, and I easily stood upright with the beam. I am relieved and grateful. For the last few weeks, I've been installing flooring, insulation and windows—all without low back pain.

–Harold, age 25

Introduction

Purpose of the Report

Senate Report 108-345–Departments of Labor, Health and Human Services, and Education, and Related Agencies Appropriation Bill, 2005, states:

> The Committee acknowledges that physical rehabilitation services are essential to the functional status and independence of individuals, particularly those dealing with musculoskeletal conditions. The Committee directs the Interagency Committee on Disability Research to report on the existing, agency-wide research activities relating to physical rehabilitation, opportunities for future physical rehabilitation research, and recommendations on how physical rehabilitation research can be enhanced within the departments and agencies, including suggestions for those areas that need to be addressed through statutory changes.

The ICDR, with this report, is responding to the Senate directive by providing the results of its survey of federal agencies on their current research activities in the area of physical rehabilitation, particularly for musculoskeletal disorders; a summary of previous accomplishments in this area of research; a review of future opportunities in the field; and general recommendations for the structuring of physical rehabilitation research.

Musculoskeletal conditions are prominent among the list of health problems that consume health dollars—both public and private—and that cause the loss of normal function. Everyone is susceptible to musculoskeletal injury; anyone may injure their bones, joints or muscles at work, during recreational activities or while performing routine daily activities.

Magnitude of Musculoskeletal Problems

Musculoskeletal Condition

Although there is no single definition of "musculoskeletal condition," a number of functional definitions do exist that are similar enough to form the basis for a consolidated definition. The NIAMS' Musculoskeletal Diseases Branch, for example, supports studies of the skeleton and associated connective tissues (U.S. Department of Health and Human Services 2005a). The U.S. Bone and Joint Decade Web site describes:

> . . . a wide range of conditions. To name just a few, we're talking about arthritis, osteoporosis, broken bones, trauma (caused by sports injuries or automobile accidents for example), back pain and other spinal disorders, hip, knee and foot pain, cerebral palsy, and congenital problems like clubfoot.

Other significant conditions include tendonitis, fasciitis, chondritis and joint instability or laxity.

For the purposes of this report we narrowly define musculoskeletal condition as any disease, injury or deformity of the following:

- Bones;
- Muscles;
- Cartilage;
- Tendons;
- Ligaments;
- Collagen;
- Fascia;
- Intervertebral discs; and
- Meniscus.

We will also look at research efforts that deal with the disease, injury or deformity of the central or peripheral nervous systems, because such nerve disorders often manifest as musculoskeletal conditions. For example, the nerve damage resulting from a stroke may manifest in an unsteady gait that causes the deformity or atrophy of leg muscles.

Impact of Disease

One leading researcher gives an excellent overview of the impact of musculoskeletal disorders:

> One typically thinks of physical rehabilitation research as that which improves the lives of people with a disability that is a result of neurological injury or disease. However, physical disability is far more often the result of musculoskeletal conditions. Knee osteoarthritis alone causes more disability with respect to mobility than any other singular disease in the elderly. One in 10 people has difficulty walking and that limitation is most commonly the result of musculoskeletal conditions. The prevalence of people with disability due to musculoskeletal conditions will grow as we live longer. The socioeconomic impact to the United States is currently already substantial (Kerrigan 2005).

Musculoskeletal conditions are prominent among the list of health problems that consume health dollars—public and private—and that cause the loss of normal function. Everyone is susceptible to musculoskeletal injury; anyone may injure their bones, joints or muscles at work, during recreational activities or while performing routine daily activities. While some members of the population are genetically predisposed to developing disorders such as arthritis, age also plays a role. The daily wear and tear on bones, joints and muscles over the span of several decades can eventually lead to musculoskeletal disorders in older individuals.

Musculoskeletal disorders often have a cumulative impact on an individual's life, in that they may lead to further injury, inactivity and physical decline. These disorders often lead to functional limitations such as difficulties in walking and may require surgery, repeated visits to physicians' offices and long-term pain medications.

Definition of Physical Rehabilitation

Physical rehabilitation should be viewed in two ways: first, as an overall idea; and second, as a set of services. In its highly influential report *Enabling America: Assessing the Role of Rehabilitation Science and Engineering* (Brandt and Pope 1997), the Institute of Medicine (IOM) defined *rehabilitation* as:

> The process by which physical, sensory and mental capacities are restored or developed in (and for) people with disabling conditions—reversing what has been called the disabling process, and may therefore be called the enabling process. This is achieved not only through functional changes in the person (e.g., development of compensatory muscular strength, use of prosthetic limbs and treatment of posttraumatic behavioral disturbances) but also through changes in the physical and social environments that surround them.

Physical rehabilitation services cover a wide spectrum. The National Rehabilitation Hospital (2005) defines *rehabilitation services* as including:

> . . . medical care, nursing care, physical therapy, occupational therapy, speech-language therapy, therapeutic recreation, vocational rehabilitation, counseling and other activities prescribed to increase a patient's independence and functional abilities.

For musculoskeletal conditions, medical and nursing care in the form of surgery and pharmaceutical treatment, rehabilitation services (most typically physical therapy and occupational therapy) and patient education and treatment planning represent the primary means of treatment. Occupational therapy and physical therapy interventions—even when similar in technique—are derived from different theoretical perspectives for each profession. For the purposes of this report, physical rehabilitation, or physical therapy clinical practice, spans a set of procedures and techniques. They include:

- **Therapeutic exercise**—such as aerobic and endurance conditioning, balance training, breathing exercises and gait training;
- **Functional training**—including training in self-care, home management, use of adaptive equipment and assistive technology and work-hardening programs[1];
- **Manual therapy techniques**—such as massage, mobilization, manipulation and passive range of motion;
- **Orthotics and prosthetics**—including the selection and provision of and training in the use of therapeutic implements and equipment, braces and artificial limbs;

[1] Work Hardening is "a highly structured goal-oriented, individualized treatment program designed to return a person to work. Work Hardening programs, which are interdisciplinary in nature, use real or simulated work activities designed to restore physical, behavioral, and vocational functions. Work hardening addresses the issues of productivity, safety, physical tolerances, and worker behaviors" (American Physical Therapy Association).

- **Airway clearance**—defined as a group of therapeutic activities intended to manage the airway;
- **Integumentary repair and protection techniques**—including wound management techniques such as the dressing of wounds and the use of support devices and topical agents; and
- **Physical agents, including electrotherapeutic modalities**—procedures using such forms of energy as hydrotherapy, light, sound and thermotherapy to assist healing, relieve pain or reduce soft tissue swelling (American Physical Therapy Association 2003).

Definition of Physical Rehabilitation Research

The "Common Rule"[2] defines *research* as "a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge" (45 CFR 46.102). The IOM distinguishes between the two levels of physical rehabilitation research: 1) pathology and impairment research, which focuses on "the altered function of molecules, cells, organs and organ systems;" and 2) functional limitation research, which focuses on "improving the capacity to perform specific activities." The IOM further distinguishes between disability research, the study of the role of the environment in fostering or reducing disability, and health services research, the analysis of models of care delivery and their effects on disability (Brandt and Pope 1997).

This report includes studies on each of the aforementioned levels, and each study reviewed contributes in some way to the goal of "not just demonstrating the effectiveness of certain treatments, but most importantly, advancing a critical basic science underlying physical rehabilitation research, which is that of overall musculoskeletal function and performance" (Kerrigan 2005).

[2] The "Common Rule" refers to Federal Policy for the Protection of Human Subjects. See http://www.hhs.gov/ohrp/policy/common.html.

Walking With a Rollator

As my 10-year-old granddaughter and I finish the last stretch of our two-mile walk, she finishes telling me about pranks she and her friends played on the counselors at the outdoor camp she attended last week. Six months ago, during her visits, we'd play checkers in my living room, while she fidgeted, eager to play outside. At that time, I could only shuffle along on two canes because of my back arthritis. I was afraid I would fall if I ventured outside.

One day during a checkup I told my primary care doctor how lonely and isolated my condition made me feel. She suggested I use a rollator. An alternative to a walker, a rollator has wheels that allow you to turn and pivot in a way that walkers cannot. Lightweight and sturdy, a rollator has a seat if you need to rest. At first I resisted because I thought I would become too dependent on it. What would be next? A wheelchair? Eventually, I decided to try it. First, I practiced using the rollator inside my apartment. Then, I went outdoors with my biggest cheerleader at my side—my granddaughter. On the first day, I made it a full block and talked with neighbors along the way. After a couple of months, I was walking a mile, focusing on the independence rather than the dependence. I started going out for bridge games and even did light grocery shopping. I'm delighted my primary care doctor suggested the rollator.

–Dan, age 86

Section 1: Methodology

Process Overview

The ICDR developed this document in four phases. Phase 1 began with the development of a draft outline for the report and the convening of an advisory committee consisting of members with expertise in physical rehabilitation research and clinical practice[3] on April 30, 2005, to discuss it. Following the meeting, the outline was revised to incorporate attendee comments and suggestions.

In Phase 2, we surveyed ICDR members to identify current rehabilitation research activities in the various agencies. This survey was sent to the membership and ICDR subcommittees in May 2005, and it was explained in the accompanying e-mail that the survey results would be collected in a compendium and reported to Congress after a review by the full ICDR membership. In addition, the e-mail gave a precise definition of research activities and development activities. (For the full text of the e-mail and member survey, see Appendix B.)

A response to the survey was received from the following agencies, institutes and offices:

- NIDRR
- U.S. Department of Health and Human Services
  - National Institutes of Health
  - Agency for Healthcare Research and Quality (AHRQ)
  - Centers for Disease Control and Prevention (CDC)
  - U.S. Food and Drug Administration
- National Science Foundation
- VHA

Phase 3 began with independent research, from which we developed a preliminary list of projects. We used the CRISP database to identify federally funded physical rehabilitation

[3] Denise Burton, Ph.D., Portfolio Manager, Chronic Medical Diseases, Rehabilitation Research and Development Service, U.S. Department of Veterans Affairs.
Bruce Gans, M.D., Chief Medical Officer, Kessler Institute for Rehabilitation, Saddle Brook, NJ.
Walter Frontera, M.D., Earle P. and Ida S. Charlton Associate Professor of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, Harvard Medical School.
Lynn Gerber, M.D, Chief, Rehabilitation Medicine Department, Clinical Center, National Institutes of Health.
Andrew A. Guccione, P.T., D.P.T., Ph.D., FAPTA, Senior Vice President for Practice and Research, American Physical Therapy Association.
Helen Hoenig M.D., Assistant Professor, Department of Medicine, Division of Geriatrics, Duke Medical Center; and Chief, Physical Medicine and Rehabilitation Service, Veterans Administration Medical Center, Durham, N.C.
E. Byron Marsolais, M.D., Ph.D., Professor of Orthopedics and Pain Management, School of Medicine, Case Western Reserve University.
Hilary C. Siebens, M.D., Principal, Siebens Patient Care Communications; and Adjunct Professor, Clinical Physical Medicine and Rehabilitation, University of Virginia.
Stephanie Studenski, M.D., M.P.H., Professor of Medicine, School of Medicine, University of Pittsburgh.
Michael Weinrich, M.D., Director, National Center for Medical Rehabilitation Research, National Institute of Child Health and Human Development, National Institutes of Health.

research efforts in addition to those identified by the agencies, institutes and offices. The CRISP database, maintained by the Office of Extramural Research at the NIH, includes projects funded by the following agencies in the U.S. Department of Health and Human Services: NIH, Substance Abuse and Mental Health Services Administration (SAMHSA), Health Resources and Services Administration (HRSA), FDA, CDC, AHRQ and the Office of the Assistant Secretary of Health (ASH).

Using the terms *musculoskeletal* and *rehabilitation* and a timeframe of the past five years, we initially identified 214 studies or other research activities that did not duplicate those identified by the agencies. We reviewed each abstract and eliminated 72 of the CRISP-retrieved studies and other research activities as being irrelevant to this report. The studies and other research activities we identified were additional studies not reported to us by the agencies, institutes and offices. This may be due to minor differences between agencies, institutes and offices in interpreting our request for information.

Through CRISP, we identified 83 individual research studies currently being funded. The number of CRISP-retrieved studies funded by each agency did not significantly change the overall picture of which agencies were the major funders of physical rehabilitation research. The addition of the National Institute of Neurological Disorders and Stroke (NINDS) to the group of funders reflects the inclusion of research on neurological disorders with musculoskeletal outcomes.

We also identified the topics covered in the 83 research studies. The topics covered in these 83 studies are represented roughly in the same proportions as the topics covered in the reported studies. The number of studies on diagnostic or measurement issues retrieved from the CRISP database represents a larger proportion of the total than in the reported group of studies.

Ten agencies, institutes and offices also sponsored other research activities retrieved through the CRISP search: NIAMS (23 activities); the NINDS (10 activities); the NICHD (8 activities); the NIA (7 activities); National Center for Complementary and Alternative Medicine (NCCAM) (3 activities); the NIH Clinical Center (3 activities); the AHRQ (2 activities); National Center for Research Resources (1 activity); NIBIB (1 activity); and the NIMH (1 activity). The activities funded included research programs, research support and small business grants.

It was in the area of "other research activities," such as those listed above, where we saw the largest divide between activities reported by the agencies, institutes and offices and activities listed in CRISP. For example, we found an additional 11 research programs on the musculoskeletal system in CRISP, covering such topics as: musculoskeletal disorder therapeutics at the University of Alabama, Birmingham; multidisciplinary research at Dartmouth College; and measurement of patient-reported outcomes at the University of Washington Center on Outcomes Research in Rehabilitation. We also identified a larger number of research support grants listed in CRISP than were listed among the responses. Again, this may reflect each organization's interpretation of our request for information as emphasizing individual studies rather than programs or research support.

Overall, the CRISP results did not significantly change the picture of current research presented by the agency responses. These results were generally similar in proportions of funders, topics and activities to those reported by the agencies, institutes and offices themselves.

Literature Search

In Phase 4, we conducted a literature search for published studies and published clinical guidelines on the following Web sites and in the following databases:

- National Library of Medicine (http://www.nlm.nih.gov/);
- National Guideline Clearinghouse (http://www.guideline.gov/);
- Cochrane Collaboration (http://www.cochrane.org/);
- National Rehabilitation Information Center (http://www.naric.com/);
- CRISP (http://crisp.cit.nih.gov/);
- National Technical Information Service (http://www.ntis.gov/);
- American Physical Therapy Association's Hooked on Evidence Web site (http://www.hookedonevidence.com/);
- American Academy of Physical Medicine and Rehabilitation, *Practice Guideline Resources* (http://www.aapmr.org/hpl/pracguide/resource.htm); and
- Thomson ISI Web of Knowledge (http://www.isinet.com/).

From the literature, the ICDR identified those physical rehabilitation studies and guidelines that appeared to be based on high-quality research (either RCTs or meta-analyses). This research, presented in figures 1-8 and table 1, illustrates the number of studies that could be used to help determine the efficacy of physical rehabilitation practices.

There are two ways to evaluate the existing body of evidence for physical rehabilitation therapies. The first involves reviewing federal organizations' own assessments of the progress of physical rehabilitation research. Unfortunately, the administrative needs of various funding agencies, institutes and offices do not lend themselves to characterizing research outcomes in a way that supports analysis of the immediate value of funded research to clinical practice. For example, it is difficult to find organization reports that discuss the outcomes of research programs in terms of effect on clinical practice.

However, one exception can be found in a publication by the National Center for Complementary and Alternative Medicine (NCCAM): *Expanding Horizons of Health Care: Strategic Plan 2005-2009* (U.S. Department of Health and Human Services 2005b). In a series of documents prepared as part of NCCAM's strategic planning effort for 2005-09, the agency has prepared research overviews in five areas: manipulative and body-based practices; biologically based practices; energy medicine; mind-body medicine; and whole medical systems. These reports provide testimony for the need to strengthen the science behind complementary and alternative modalities.

In the area of manipulative and body-based practices, the authors noted important gaps in the field, as revealed by a review of the relevant scientific literature, including the following:

- Lack of biomedical characterization from both practitioner and participant perspectives;
- Little use of state-of-the-art imaging techniques;
- Few data on the physiological, anatomical and biomechanical changes that occur with treatment;
- Inadequate data on the effects of these therapies at the biochemical and cellular levels; and
- Only preliminary data on the physiological mediators involved with the clinical outcomes.

The second way to evaluate the existing body of evidence is to perform a literature review using influential sources such as the NLM's PubMed or the Cochrane Collaboration. Here the assumption is that high-quality studies (such as the RCTs) and clinical guidelines will influence clinical practice as a result of dissemination through these respected databases, literature collections and Web sites.

The result of these database and literature searches testifies to the nascent state of scientifically based physical rehabilitation research. Table 1 shows how physical rehabilitation research compared to cardiology research, a highly developed area of clinical practice. To give an idea of the magnitude of available research for the latter, we searched for references on a single cardiology procedure, *coronary artery bypass graft* (CABG) in the same databases and Web sites as those used to search for references to physical rehabilitation research, and compared the number of musculoskeletal rehabilitation results to the number of studies retrieved on CABG.

The numbers in table 1 demonstrate that a higher number of the RCTs have been published for CABG than for all musculoskeletal rehabilitation topics combined (979 versus 266, respectively). Similarly, the 27 clinical guidelines for the CABG procedure significantly outnumber the single published clinical guideline on the topic of musculoskeletal rehabilitation. More general clinical guidelines covering the musculoskeletal system or musculoskeletal disorders, which may include some guidance on rehabilitation, also are less numerous (20) than those published for the CABG procedure.

The number of meta-analyses requires some additional interpretation. Although a higher number of meta-analyses have been published on musculoskeletal disorders and the musculoskeletal system than have been published on the topic of CABG, when the scope of the search is narrowed to include only musculoskeletal rehabilitation topics and to exclude studies of etiology and curative treatments, the number of meta-analyses drops significantly to 20.

Table 1. Literature search results, by type of study or guideline and number retrieved

Type of study or guideline	Number retrieved
RCTs on musculoskeletal rehabilitation topics	258
RCTs on musculoskeletal disorders/musculoskeletal system	8
RCTs on CABG	979
Guidelines on musculoskeletal rehabilitation topics	1
Guidelines on musculoskeletal disorders/musculoskeletal system	20
Guidelines on CABG	27
Meta-analyses on musculoskeletal rehabilitation topics	20
Meta-analyses on musculoskeletal disorders or musculoskeletal systems[a]	167
Meta-analyses on CABG[a]	40

Source: PubMed database; National Guideline Clearinghouse; Cochrane Collaboration; National Rehabilitation Information Center; CRISP database; National Technical Information Service; American Physical Therapy Association's Hooked on Evidence Web site; American Academy of Physical Medicine and Rehabilitation, *Practice Guideline Resources; and* Thomson ISI Web of Knowledge.

[a] Includes Cochrane Reviews.

Selection Criteria

We relied on each individual agency, institute or office to define *physical rehabilitation research*. In this report we included all studies submitted by the responding agencies, institutes and offices. For the literature search, we included research studies and clinical guidelines that fell within the broad definition of "musculoskeletal condition" described above; that is, any research on:

- Bones;
- Muscles;
- Cartilage;
- Tendons;
- Ligaments;
- Collagen;
- Fascia;
- Intervertebral discs;
- Meniscus; and
- Diseases, injuries or deformities of the central or peripheral nervous systems, with any musculoskeletal outcome.

In terms of rehabilitation, we included research on:

- Standard rehabilitation therapies such as therapeutic exercise, functional training, electrotherapy or physical agents;
- Research on surgical or pharmacotherapeutic treatments;
- Research on treatments not yet standard within therapist clinical practice such as gene therapy or virtual reality therapy;
- Research on complementary and alternative medicine;
- Research on behavioral interventions, including means to enhance wellness and self-efficacy; and
- Studies of assistive technology for persons with musculoskeletal or neuromuscular disorders, particularly those with a rehabilitative goal (e.g., a "smart" knee brace designed to improve functional mobility).

Constraints and Limits on Assessing Research

Readers should be aware of some constraints on the research assessment presented in this report. First, in terms of the reported studies and activities, we relied on each individual agency, institute or office to define *physical rehabilitation research.* Each agency, institute or office may differ slightly in the kind of research it would include in this category. Agencies, institutes and offices were not able to provide funding data for current studies due to varying funding periods. The data also does not capture information on projects currently in the funding application process (i.e., not yet awarded).

The literature search does not present an exhaustive review of all published studies and clinical guidelines. Although our search strategy was based on key terms relating to musculoskeletal conditions, it is possible that individual databases or Web sites may classify some musculoskeletal studies under variant keywords.

Analysis

A spreadsheet was created in which each study or other activity was categorized by the following:

- Agency;
- Subagency, Institute or Office;
- Award, Protocol or Grant Number;
- Category (Award Type);
- Period of Performance;
- Topic;

- Core Musculoskeletal Definition[4] or Extended Musculoskeletal Definition;[5]
- Core Physical Rehabilitation Definition[6] or Extended Physical Rehabilitation Definition;[7]
- Applicability to Practice;[8]
- Title of Study; and
- Capacity-building.[9]

The categories of "Agency," "Subagency, Institute or Office," "Award, Protocol or Grant Number," "Category (Award Type)," "Period of Performance," and "Title of Study" were all taken directly from records sent by the agencies, institutes and offices. The remaining 17 categories were created by CESSI in an attempt to make useful, logical groupings of studies for the purposes of the analysis. We developed the categories based on the studies' abstracts and looking for logical groupings. We differentiated between "core" and "extended" definitions of musculoskeletal conditions in order to review studies of conditions with a neurological component while keeping them separate from studies of musculoskeletal conditions as strictly defined. Similarly, for the purposes of comparison, we broke down the physical rehabilitation category into two subcategories—"core" and "extended" therapies—based on whether or not they formed a part of standard therapist practice.

The subjective rating "Applicability to Practice" simply suggests the likelihood that the treatment being researched would enter clinical practice during one of the three time periods (three years; between three and 10 years; or over 10 years). And for each study we assigned a "yes" or "no" in the "Capacity-building" category based on whether the researcher included a teaching function among the stated research goals.

We also received information from agencies, institutes and offices on other types of research efforts such as funding for small business innovation, symposia, conferences and research centers. These research efforts were categorized as follows:

- Activity Type;
- Agency;
- Subagency, Institute or Office;
- Award, Protocol or Grant Number;
- Category (Award Type);
- Period of Performance;
- Description;

[4] Studies strictly concerned with bone, muscle, intervertebral disc, meniscus and connective tissues.
[5] Studies strictly concerned with neurological disease, injury or deformity.
[6] Studies on physical rehabilitation procedures and techniques such as exercise, functional training, electrotherapy or physical agents.
[7] Surgical or pharmacological treatments or other treatments not currently part of physical therapist or occupational therapist practice such as gene therapy or virtual reality.
[8] Rating of the likelihood that the research would lead to changes in clinical practice within: 1) three years; 2) between three and 10 years; or 3) over 10 years.
[9] Whether the study is part of an effort to build research capacity by supporting physical rehabilitation researchers.

- Web site; and
- Capacity-building.

The information in many of these categories was taken directly from data submitted by the agencies, institutes and offices. The studies were categorized by “Activity Type” to group similar kinds of activities such as professional development grants, and we reviewed each activity to determine whether it contained a capacity-building goal.

Physical Therapy for an Orthopedic Injury

After a couple of miles of cruising along the bike path, admiring the rowers on the river—not thinking about my impending surgery for Crohn's disease—I rounded a curve and came within inches of another bicycle in front of me. Swerving to avoid a collision, I stumbled and fell, landing on my elbow. I felt a stabbing pain. Even worse was the sight of my elbow, which was bent backward towards my ear.

I wore a cast for six weeks. When it was removed, I was alarmed at the position of my elbow, which was still unnaturally bent. Determined to get back to normal, I started physical therapy, but made little progress that first month. I continued to struggle with everyday activities like combing my hair and fastening buttons on the back of my clothes. I also worried about the cost of the therapy because my parents' insurance covered only a small portion of my visits. Reluctantly I saw a surgeon who recommended surgery to straighten out my arm. I balked at having surgery for both my Crohn's disease and my elbow during my three months off from college. Steeled with resolve, instead of surgery I did the exercises the physical therapist had shown me. My arm eventually started improving, and within two years, it was back to normal. I only wished the surgeon and the physical therapist had given me more assurance.

–Kyla, age 19

Section 2: Research Status

Current Practices

The volume and types of physical rehabilitation therapy being provided to the U.S. public are based on a history of clinical practice and the idea that these treatments are effective for at least some patients. In recent years, there has been a growing number of attempts to understand which of these treatments is truly effective and for which subsets of patients. Such an understanding is necessary to tailor optimal treatments to patients and minimize unnecessary costs.

Several questions are relevant to establishing the effectiveness of physical rehabilitation practices:

- What broad categories of therapy (e.g., exercise) are helpful to patients with a particular musculoskeletal condition such as osteoarthritis?
- Within a broad therapy category such as exercise, are there specific types of therapy or amounts of therapy that provide the greatest benefit to patients with a particular musculoskeletal condition?
- Can we distinguish specific types of treatment that provide a long-term rather than a short-term benefit?
- Can a specific treatment be improved to become even more effective?
- Can one or more specific treatments be combined to produce a stronger positive effect than each would have if applied individually?

We worked with members of the advisory committee for this report to identify key research results that had begun to establish an evidence base for effective physical rehabilitation practice. We found that many of the studies addressed the first question regarding broad categories of therapy, but few studies addressed the remaining questions of therapy types, amounts, combination and duration of effect, as well as potential improvements to existing therapies. The emphasis on comparing broad categories of therapy (such as exercise versus bed rest) is, however, a necessary first step toward eliminating non useful practices and refining effective therapies.

The following broad categories of therapy are based on literature recommended by the advisory committee, and includes the randomized controlled trials (RCTs), controlled clinical trials, systematic reviews and published reviews by expert panels.

Exercise

The broad category of therapy for which the largest body of supporting evidence exists is exercise (table 2). Eleven RCTs and controlled clinical trials reported positive outcomes for exercise for such conditions as back pain (Herbert et al. 2001; Jette and Jette 1996; Long, Donelson, and Fung 2004; Nordin and Campello 1999; O'Sullivan et al. 1997; Timm 1994; Hayden et al. 2005), hip fractures (Binder et al. 2004,) and chronic Achilles tendinosis (Alfredson et al. 1998; Fahlstrom et al. 2003; Mafi, Lorentzon, and Alfredson 2001). Five advisory panels offered positive assessments of exercise for patients with rheumatoid arthritis

(Ottawa Panel 2004a), osteoarthritis (Ottawa Panel 2005), low back pain (Philadelphia Panel 2001a), knee pain (Philadelphia Panel 2001b) and neck pain (Philadelphia Panel 2001c). Likewise, a Cochrane Review concluded that exercise may be helpful for chronic low back pain patients (Hayden et al. 2005).

Electrotherapy or Thermotherapy

Electrotherapy or thermotherapy interventions (table 3; low-level laser therapy, therapeutic ultrasound, thermotherapy, electrical stimulation, transcutaneous electrical nerve stimulation and electromagnetic therapy) also received support in the set of publications we reviewed. Both an individual RCT (Snyder-Mackler et al. 1995) and a panel review (Philadelphia Panel 2001b) found positive outcomes for electrotherapy or thermotherapy for knee pain. Two other panel reports supported the use of such therapies for rheumatoid arthritis (Ottawa Panel 2004b) and shoulder pain (Philadelphia Panel 2001d). And electromagnetic therapy was found to have a reported positive outcome for patients with neck pain in a systematic review of 27 RCTs (Kjellman, Skargren, and Oberg 1999).

Manual Therapy

Manual therapy (table 4) encompasses a set of treatment techniques consisting of passive physiologic and accessory joint movements, muscle stretching and soft-tissue mobilization. Korthals-de Bos et al. (2003) reported an RCT in which 183 patients were randomly assigned to manual therapy, physiotherapy/exercise or general practitioner care for neck pain. In this study, manual therapy was more effective than the other treatments for several outcome measures such as pain and perceived recovery. Gross et al. (1996) and Kjellman, Skargren, and Oberg (1999), in two systematic reviews of the RCTs and before-and-after studies, concluded that manual therapy treatment was effective in reducing pain from neck disorders.

Physiotherapy

Physiotherapy (table 5; usually a combination of various treatments most often used to describe services provided by physical therapists) was also found to be effective for some musculoskeletal disorders. One systematic review (Kjellman, Skargren, and Oberg 1999) and two individual RCTs (George et al. 2003; Persson, Carlsson, and Carlsson 1997) compared the effectiveness of physiotherapy to treatments such as surgery or the use of a cervical collar, or neckbrace, for neck pain, and found that physiotherapy was at least equally effective to other treatments. George et al. (2003) found that tailoring the treatment to the patient's psychological profile added to the effectiveness of the intervention.

Advice to Continue Normal Activities

Many of the recommendations for the treatments discussed above are appropriate for patients with chronic back pain. For acute back pain such as that originating from a sports injury, reassurance and advice to continue normal activities was found to be effective (table 6). Herbert et al., in a clinical review published in 2001, concluded that "there is strong evidence from recent studies that simple interventions provided soon after onset of symptoms can prevent the

development of chronic back pain." The Philadelphia Panel (2001b) found "continuation of normal activities" to be the only effective intervention for acute low back pain.

Exercise Combined With Manual Therapy

The findings in tables 2-6 resulted from comparisons of single interventions, such as exercise versus thermotherapy or physiotherapy versus bed rest. A smaller number of studies compared a combined exercise and manual therapy intervention against another form of treatment (table 7). In one RCT, Bang and Deyle (2000) found that exercise, combined with manual therapy, was significantly more effective than exercise alone for treatment of shoulder impingement syndrome. Similarly, Deyle et al. (2000) found that "a combination of manual physical therapy and supervised exercise yields functional benefits for patients with osteoarthritis of the knee." The Ottawa Panel concurred with this recommendation in its 2005 review of therapies for osteoarthritis.

Multidisciplinary Rehabilitation Programs

Multidisciplinary rehabilitation programs, because they may combine several types of treatment, were among the more difficult to evaluate (table 8). In addition, it was difficult to characterize an intervention as multidisciplinary when it involved care that might be offered in a chronic pain program by a group of providers (physiatrists, neurologists, psychologists, physical therapists and social workers) all acting in concert. These studies may be better described as "combined multimodal approaches," usually provided by a single professional. There are two studies in this report that offer an initial assessment of this type of multimodal care. In an observational study of outcomes experienced by 138 patients in a multidisciplinary program, DiFabio, Mackey, and Holte (1995) found that patients with a high level of compliance to a program—including heating modalities, passive stretching, spinal mobilization, active exercise and lifting instructions—experienced better outcomes than did less compliant patients. A pre- and post-treatment study among 26 patients found multimodal therapy to be helpful to patients with chronic pain resulting from whiplash (Vendrig, van Akkerveeken, and McWhorter 2000).

Predictive Evaluation Schemes

The ability to predict which patients will benefit from a treatment is desirable because it allows health personnel to tailor treatments more closely to the patients (table 9). Researchers are conducting studies and performing record reviews in an attempt to build predictive evaluation schemes that can be tested on future patients. For example, Childs et al. (2004) tested a set of predictive criteria among 131 patients with low back pain. They were able to develop a set of criteria, including symptom duration and lumbar mobility, that were predictive of the outcome from spinal manipulation. In 2002, the Heart and Stroke Foundation of Ontario published a clinical guideline that clinicians use to help shape their care of patients with hemiplegic arm and hand due to stroke. The guideline includes predictive criteria.

Summary

These categories, research programs and methods present a base for understanding the effectiveness of current physical rehabilitation therapies. Researchers continue to add to this base

through new studies and reviews. In addition, some researchers are beginning to study the effects of variations in timing or the intensity of interventions. Jette, Warren, and Wirtalla (2005), for example, performed a retrospective record review of 4,988 patients, including those recovering from a stroke, those with orthopedic conditions and those receiving treatment in skilled nursing facilities. The authors of the record review were able to quantify the level of therapy intensity and concluded that higher therapy intensities were associated with better outcomes. Current and future research efforts may build on this knowledge base to better understand the effects of combined treatments, multidisciplinary treatments, predictive schemes and other factors influencing treatment outcome.

Table 2. Findings from clinical trials on the effectiveness of exercise on musculoskeletal conditions, by type of study

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Chronic Achilles tendinosis	Heavy-load eccentric calf muscle training was significantly more effective than conventional treatment.	RCT, Non-random case series, Multicenter RCT	Alfredson et al. 1998; Fahlstrom et al. 2003; Mafi, Lorentzon, and Alfredson 2001
Hip fracture	Six months of extended outpatient rehabilitation that included progressive resistance training could improve physical function.	RCT	Binder et al. 2004
Anterior cruciate ligament damage	A perturbation training program appeared to reduce the risk of continued episodes of giving way of the knee.	RCT	Fitzgerald, Axe, and Mackler-Snyder 2000
Chronic musculoskeletal pain	Exercise programs can reduce disability associated with back pain.	Clinical review of the RCTs and systematic reviews	Herbert et al. 2001
Spinal impairments	Inclusion of endurance exercises in a course of physical therapy care was associated with improvement in nearly all health scales.	Retrospective analysis of secondary data	Jette and Jette 1996
Nonspecific low back pain	Exercises were beneficial for patients with subacute and chronic, nonspecific low back pain.	Systematic review	Nordin and Campello 1999
Chronic low back pain	Exercise training of the muscles surrounding the spine was more effective than other commonly prescribed conservative treatment programs.	RCT	O'Sullivan et al. 1997

Table 2 *(continued)*

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Chronic low back pain following surgery	Low-tech exercise was the most cost-effective form of treatment for pain relief.	RCT	Timm 1994
Low back pain	Provision of exercise tailored to each individual's "directional preference" of movement significantly decreased pain and medication use.	Multicenter RCT	Long, Donelson, and Fung 2004
Low back pain	Therapeutic exercises were beneficial for chronic, subacute and postsurgical low back pain.	Systematic review	Philadelphia Panel 2001a
Low back pain	A Cochrane Review concluded that exercise may be helpful for chronic low back pain patients.	Systematic review	Hayden et al. 2005
Rheumatoid arthritis	Therapeutic exercises recommended to reduce pain.	Systematic review	Ottawa Panel 2004a
Osteoarthritis	Therapeutic exercises recommended for the management of pain and improvement of functional status.	Systematic review	Ottawa Panel 2005
Knee pain	Therapeutic exercises were beneficial for pain relief in people with knee osteoarthritis.	Systematic review	Philadelphia Panel 2001b
Neck pain	Therapeutic exercises were the only intervention with clinically important benefits of reducing pain and improving function.	Systematic review	Philadelphia Panel 2001c

Source: Alfredson et al. 1998; Fahlstrom et al. 2003; Mafi, Lorentzon, and Alfredson 2001; Binder et al. 2004; Fitzgerald, Axe, and Mackler-Snyder 2000; Herbert et al. 2001; Jette and Jette 1996; Nordin and Campello 1999; O'Sullivan et al. 1997; Timm 1994; Long, Donelson, and Fung 2004; Philadelphia Panel 2001a; Hayden et al. 2005; Ottawa Panel 2004a; Ottawa Panel 2005; Philadelphia Panel 2001b; and Philadelphia Panel 2001c.

Table 3. Findings from clinical trials on the effectiveness of electrotherapy and thermotherapy on musculoskeletal conditions, by type of study and source

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Neck pain	Electromagnetic therapy had a reported positive outcome for pain, range of motion and activities of daily living (ADL).	Systematic review	Kjellman, Skargen, and Oberg 1999
Rheumatoid arthritis	Recommendation for the use of low-level laser therapy, therapeutic ultrasound, thermotherapy, electrical stimulation and transcutaneous electrical nerve stimulation.	Systematic review	Ottawa Panel 2004b
Shoulder pain	Ultrasound provided pain relief for patients with calcific tendonitis.	Systematic review	Philadelphia Panel 2001d
Knee pain	Transcutaneous electrical nerve stimulation was beneficial for knee osteoarthritis.	Systematic review	Philadelphia Panel 2001b
Knee (anterior cruciate ligament) reconstruction	Neuromuscular electrical stimulation plus exercise was effective for regaining muscle strength in the affected knee.	RCT	Snyder-Mackler et al. 1995

Sources: Kjellman, Skargen, and Oberg 1999; Ottawa Panel 2004b; Philadelphia Panel 2001d; Philadelphia Panel 2001b; and Snyder-Mackler et al. 1995.

Table 4. Findings from clinical trials on the effectiveness of manual therapy on musculoskeletal conditions, by type of study and source

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Mechanical neck disorders	Recommendation for the use of manual therapy in combination with other treatments such as drug therapy, patient education and physical medicine modalities.	Systematic review	Gross et al. 1996
Neck pain	Manipulation had a reported positive outcome for pain, range of motion and ADL.	Systematic review	Kjellman, Skargen, and Oberg 1999
Neck pain	For outcome measures such as perceived recovery and pain level, manual therapy was more effective than physiotherapy combined with exercise.	RCT	Korthals-de Bos et al. 2003

Source: Gross et al. 1996; Kjellman, Skargen, and Oberg 1999; and Korthals-de Bos et al. 2003.

Table 5. Findings from clinical trials on the effectiveness of physiotherapy on musculoskeletal conditions, by type of study and source

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Mechanical neck disorders	Recommendation for the use of a "fear-avoidance-based" physical therapy intervention for those patients with elevated fear-avoidance issues.	RCT	George et al. 2003
Neck pain	Active physiotherapy had a reported positive outcome for pain, range of motion and ADL.	Systematic review	Kjellman, Skargen, and Oberg 1999
Cervical radicular pain	Physiotherapy was effective in reducing pain at one year following treatment.	RCT	Persson, Carlsson, and Carlsson 1997

Source: George et al. 2003; Kjellman, Skargen, and Oberg 1999; Persson, Carlsson, and Carlsson 1997.

Table 6. Findings from clinical trials on the effectiveness of advice to continue normal activities on musculoskeletal disorders, by type of study and source

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Chronic musculoskeletal pain	Early provision of reassurance and advice to continue normal activities can prevent chronic disability associated with back pain.	Clinical review of the RCTs and systematic reviews	Herbert et al. 2001
Low back pain	Continuation of normal activities was the only intervention with beneficial effects for acute low back pain.	Systematic review	Philadelphia Panel 2001a

Source: Herbert et al. 2001; and Philadelphia Panel 2001a.

Table 7. Findings from clinical trials on the effectiveness of exercise and manual therapy on musculoskeletal disorders, by type of study and source

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Shoulder impingement syndrome	Exercise with manual therapy was significantly more effective than exercise alone.	RCT	Bang and Deyle 2000
Osteoarthritis of the knee	Recommendation for a combination of manual physical therapy and supervised exercise.	RCT	Deyle et al. 2000
Osteoarthritis	Recommendation for the use of therapeutic exercise combined with manual therapy.	Systematic review	Ottawa Panel 2005

Source: Bang and Deyle 2000; Deyle et al. 2000; and Ottawa Panel 2005.

Table 8. Findings from clinical trials of the effectiveness of multidisciplinary rehabilitation programs on musculoskeletal conditions, by type of study and source

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Low back pain	Patients with low back pain with a high level of compliance to a physical therapy program with multiple interventions did better than other patients.	Observational study	Di Fabio, Mackey, and Holte 1995
Whiplash injury of the neck	Study results indicate that multimodal treatment has the potential to be an effective treatment for patients with chronic pain following whiplash.	Pre- and post-treatment study	Vendrig, van Akkerveeken, and McWhorter 2000

Source: Di Fabio, Mackey, and Holte 1995; and Vendrig, van Akkerveeken, and McWhorter 2000.

Table 9. Findings from clinical trials of the effectiveness of predictive evaluation schemes on musculoskeletal conditions, by type of study and source

Musculoskeletal condition	Findings from clinical trials	Type of study	Source
Low back pain	A multicenter RCT established the value of a spinal manipulation clinical prediction rule to determine which patients with back pain will benefit from spinal manipulation.	Multicenter RCT	Childs et al. 2004
Back and neck pain	This study found that the use of a physical therapist was associated more with demographic characteristics such as age and sex than with diagnostic criteria.	Retrospective review	Freburger, Carey, and Holmes 2005a; Freburger, Carey, and Holmes 2005b
Hip fracture	This study found support for five factors that may predict postfracture independence in functional activities: personal, medical, surgical, hospital and acute care rehabilitation variables.	Prospective data collection	Guccione, Fagerson, and Anderson 1996
Stroke, hemiplegic arm and hand	Recommendation to choose compensatory versus remedial intervention methods to treat clients who are predicted to have a low return of motor function and poor functional use of their arms and hands.	Clinical practice guideline	Heart and Stroke Foundation of Ontario 2002

Source: Childs et al. 2004; Freburger, Carey, and Holmes 2005a; Freburger, Carey, and Holmes 2005b; Guccione, Fagerson, and Anderson 1996; and Heart and Stroke Foundation of Ontario 2002.

Current Federally Funded Projects

There are several ways in which an agency, institute or office may advance physical rehabilitation research. In addition to individual research projects, funding was also reported for:

- Research programs;
- Research networks;
- Research support;
- Training programs;
- Small Business Innovation Research (SBIR) grants;
- Small Business Technology Transfer (STTR) grants; and
- Conferences.

Funding Agencies

The primary agencies, institutes and offices funding physical rehabilitation research at present are the National Institute of Child Health and Human Development (NICHD), reporting 61 active studies; the Veterans Health Administration's (VHA) Office of Research and Development, reporting 39 active studies; the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), reporting 29 active studies; the National Institute for Biomedical Imaging and Bioengineering (NIBIB), reporting 17 active studies; and the Department of Education's National Institute on Disability and Rehabilitation Research (NIDRR), reporting 14 active studies. Figure 1 presents the number of current studies, by topic, that are funded by each agency, institute or office. These agencies, institutes and offices are also the primary sponsors of conferences, research programs and other research-support activities.

Research Topics

One way to look at the overall physical rehabilitation research effort is to examine current research efforts under individual research topics. This perspective shows the extent of the research being done in a topic area and also shows each organization's contribution to this body of research. In the sections that follow, we briefly discuss each topic area in terms of volume, focus and sponsorship of research.

Cellular Biology or *Biomechanics* (80 studies): Because this topic area encompasses the structures and processes that may underlie musculoskeletal disorders, it covers a wide range of subjects. NIAMS, NIBIB and the NICHD are leaders in funding this kind of research. NIAMS is investigating issues such as etiologic factors for tendon degeneration, while NIBIB funds studies examining the biomechanical basis on which neuroprostheses may be built. The NICHD is providing financial support for studies on: biomechanical adaptations for strength training in osteoarthritis patients; studies of muscle function in surgically altered limbs; and the effects of neural constraints on movement in stroke patients.

Neurological Function (76 studies): NIAMS, NIBIB, the NICHD, the VHA and NIDRR are all investigating the details of neurological functions that may underlie musculoskeletal disorders or that may contribute to recovery and improved function. Many of these efforts, such as the NICHD's study of neuromechanical modeling of postural responses and the VHA's study of mechanisms of upper-extremity motor recovery in post-stroke hemiparesis, are designed to better understand the biology of movement.

Device Design (45 studies): Device design, including the design of orthotics and prosthetics, is a key area of physical rehabilitation research, because such devices often can improve function in individuals with disabilities as well as help prevent further impairment. The VHA is a leader in funding under this topic, currently sponsoring 23 studies, many of which are investigating new or improved design for orthotics and prosthetics. NIBIB also sponsors 13 studies on the interface between the nervous system and rehabilitative devices. In one study, NIBIB researchers are working on developing a networked implantable neuroprosthesis.

Exercise (34 studies): Reflecting its potential importance as an effective therapy for a wide range of disorders, exercise studies are currently supported by the Centers for Disease Control and Prevention (CDC), the National Institutes of Health (NIH) National Heart, Lung and Blood Institute (NHLBI), the NIH National Institute on Aging (NIA), NIAMS, the NICHD, the NIH National Institute of Dental and Craniofacial Research (NIDCR), NIDRR and the VHA. Conditions for which exercise is being investigated as therapeutic include rheumatoid arthritis, osteoarthritis, arterial disease, vascular abnormalities, hip fractures, knee arthroplasty, mobility limitations and low back pain.

Rehabilitation Therapies (33 studies): One fundamental task of physical rehabilitation research is to test current or proposed therapies. NIDRR, NIAMS and the NICHD fund the majority of the reported studies of rehabilitation therapies currently being conducted. NIDRR studies are looking at the outcomes of electronically stimulated leg cycle ergonometry, the effect of task practice in children with cerebral palsy, and the role of an intervention to promote physical activity in persons with arthritis.

Soft Tissue (33 studies): In line with its mission to understand arthritis and musculoskeletal disorders, NIAMS is a leading funder of research in soft tissue structure and function with 19 studies. NIAMS is investigating the molecular mechanisms of joint repair, the processes underlying tendon healing and the means to promote the rehabilitation of skeletal muscle.

Diagnostic or *Measurement Issues* (26 studies): The NICHD, with 12 studies, and NIDRR, with five studies, fund the majority of current studies on diagnostic or measurement issues. Studies conducted under this topic are designed to lead to improvements in such areas as measurement of patient-reported outcomes, detection of molecular signatures of muscle rehabilitation, measurement of functional performance and gait analysis.

Muscle (22 studies): Studies under this topic often may be cross-classified under other topic areas such as cellular biology, biomechanics or exercise. All of the studies in this area seek to understand the biology of muscle and the response of muscle to therapeutic interventions. The NICHD sponsors approximately half of the currently reported research in this area with 10 studies.

Amputations (20 studies): Amputation research encompasses the study of prosthetics and orthotics as supports for improved function, maintenance of the health of the residual limb and vascular system, prevention of secondary disability, and research into the possibilities offered by nerve-muscle grafts. The VHA currently funds half of these efforts with 10 studies. The NICHD funds seven studies. The CDC has funded an experimental study, *Promoting Amputee Life Skills*, which will shed light on the efficacy of community-based self-management in promoting improved function and the lessening of pain among persons with limb loss.

Mobility (16 studies): Mobility is dependent on neurological and physical functional abilities as well as on manageable or negligible pain levels. Mobility can also be affected by an individual's orthotic or prosthetic device. Because of this, these studies may be cross-classified under a variety of topic areas. For the studies in this topic area, the NICHD is the leading funder with 10 studies, followed by the VHA with four. These studies look at such specific areas as instability and muscular demand during obstacle crossing, the design of a hybrid orthosis with controllable joints, and walking aids in the management of obesity-related knee osteoarthritis.

Robotic or *Automated Therapy* (13 studies): A number of agencies, institutes and offices are sponsoring work in this area. NIDRR, the NICHD and the VHA are conducting studies of the effectiveness of robotic or automated therapy to help restore function to individuals who have suffered a stroke. The VHA is also looking at the potential for robotic or automated therapy to help individuals with spinal cord injury.

Surgery (9 studies): The agencies, institutes and offices reported a small number of studies specifically investigating surgical outcomes. For example, NIAMS is investigating outcomes of rheumatoid hand arthroplasty and mechanisms of flexor tendon healing following surgery. The National Institute of Nursing Research (NINR) is looking at the effect of prehabilitation on the rehabilitation of total knee arthroplasty patients, and the Agency for Healthcare Research and Quality (AHRQ) is studying the impact of gait analysis on surgical outcomes.

Pain Management (9 studies): Pain management is a typical outcome variable in most studies; in these nine studies, pain management is the primary focus. Low back pain is the subject of four of the nine studies (one by NIAMS and three by the NICHD).

Organization of Service Delivery (7 studies): Once the value of rehabilitation therapies has been established, the next step is to research the best way to deliver them. The NICHD is a leading funder in this area, sponsoring six of the seven current studies. The NICHD is examining the value of rehabilitation services for amputees, the relationship between community participation and rehabilitation outcomes, and how access affects outcomes of rehabilitation services.

Bone (7 studies): A small number of studies on bone were reported by the agencies, institutes and offices. The Food and Drug Administration's (FDA) Center for Devices and Radiological Health (CDRH) is performing fatigue testing of bone cement, and NIAMS is looking into the effect of fixation in total knee replacement as well as biomimetic materials useful for rehabilitation.

As figure 1 demonstrates, the number of funded studies cover a variety of research topics and represent a mix of investigatory methods. "Cellular Biology or Biomechanics" is the most frequently reported category of research, with 80 active studies reported. Such studies as *Nerve-Muscle Grafts in Amputees for Prosthesis Control* and *Pattern Formation of Vascular Smooth Muscle Cells Subject to Mechanical Stretch* will lay the groundwork for tomorrow's rehabilitation therapies.

Diagnostic and measurement issues are also represented, with 26 active studies. Researchers are currently investigating ways to measure hand function, muscle strength, work capacity and functional performance. They are also developing ways to measure pressure on muscle and tissue, with the goal of preventing pressure ulcers. Increased ability to diagnose and measure disabling conditions will lead to better understanding of which treatments are effective. For example, one of the current studies aims to develop practical measures of gait dynamics that can be used to augment clinical assessment of chronic disabling diseases like knee osteoarthritis, Parkinson's disease and amyotrophic lateral sclerosis.

Rehabilitation therapies are also under investigation, with 33 studies being funded. Such studies as *Mechanisms of Specific Trunk Exercises in Low Back Pain* and *Mental Imagery to Reduce Motor Impairments in Stroke* may lead to better clinical decisions in judging the value of therapeutic alternatives. A path toward robotic or automated therapy is represented by 13 studies, including *Virtual Reality Rehabilitation of Hand Use After Stroke* and *Mechanical Intervention in Children With Cerebral Palsy.* Robotic or automated therapy involves the use of devices to partially or completely take the place of human therapists or to provide the kinds of therapy that human therapists cannot provide. Researchers at Children's Hospital in Los Angeles, for example, are currently studying a new "whole-body vibration" intervention for low bone mass and poor muscle function in children with cerebral palsy. This intervention involves having the child stand on a platform that vibrates either up and down or in a rocking motion. If this intervention proves helpful, it may reduce the amount of traditional physical therapy required. Such studies show promise for developing therapies that are both effective and that reduce the need for scarce human resources.

The studies also show a balance between "core definition" and "extended definition" musculoskeletal conditions. The former involves studies that are strictly concerned with bone, muscle, intervertebral disc, meniscus and connective tissues. The latter involves "extended definition" conditions, i.e., studies that are concerned with neurological disease, injury or deformity (fig. 2). There are 100 studies under the core musculoskeletal definition and 91 under the extended definition. Likewise, the studies fall fairly evenly into the two definitions of physical rehabilitation therapy. "Core definition" therapies involve studies on physical rehabilitation procedures and techniques such as exercise, functional training, electrotherapy or physical agents. "Extended definition" therapies include surgical treatments or other treatments not currently part of therapist clinical practice, such as gene therapy or virtual reality (fig. 3). There are 100 studies under the core definition of therapy and 91 studies under the extended definition.

Figure 1. Number of current federally funded studies, by topic area and agency, institute or office

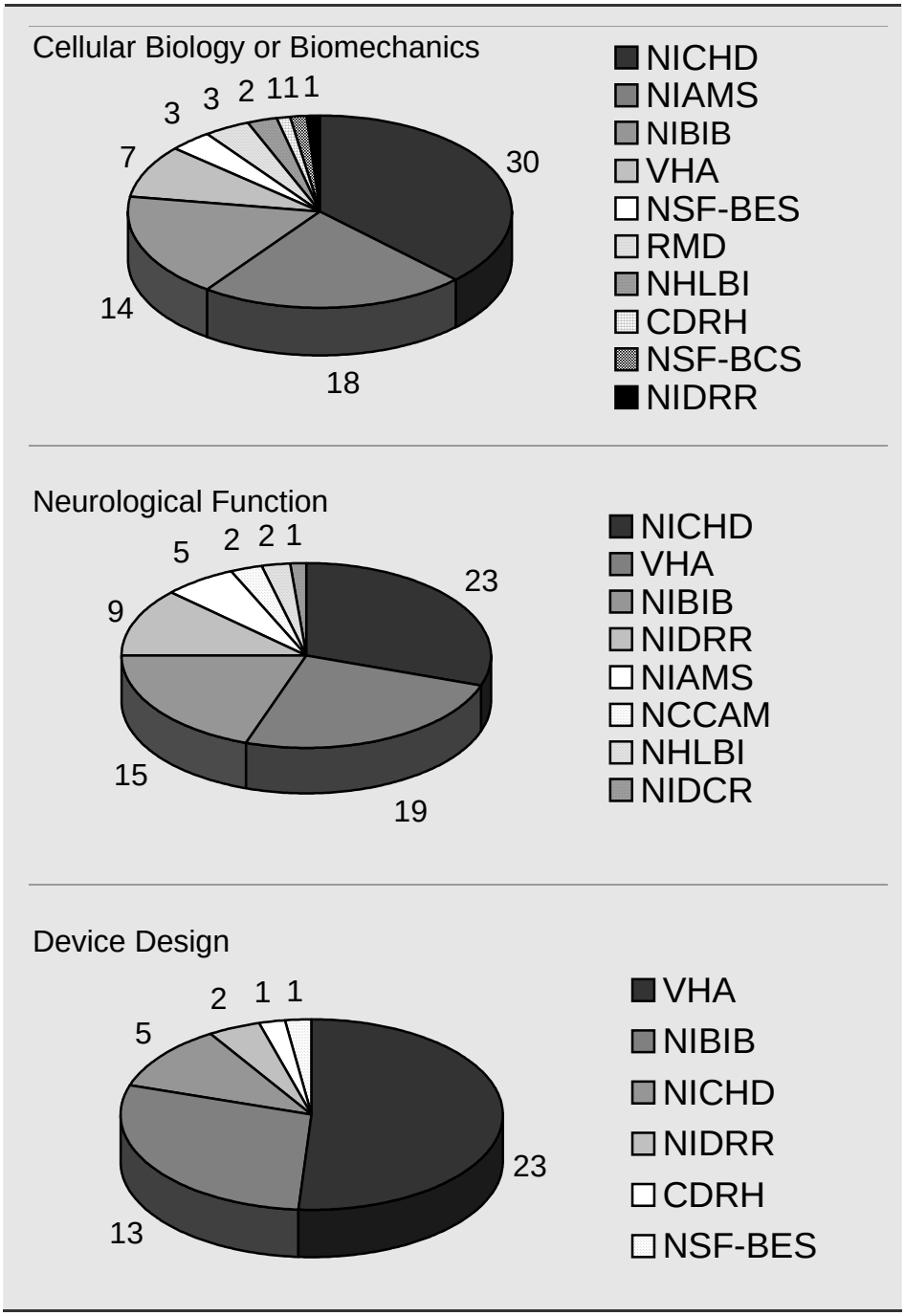
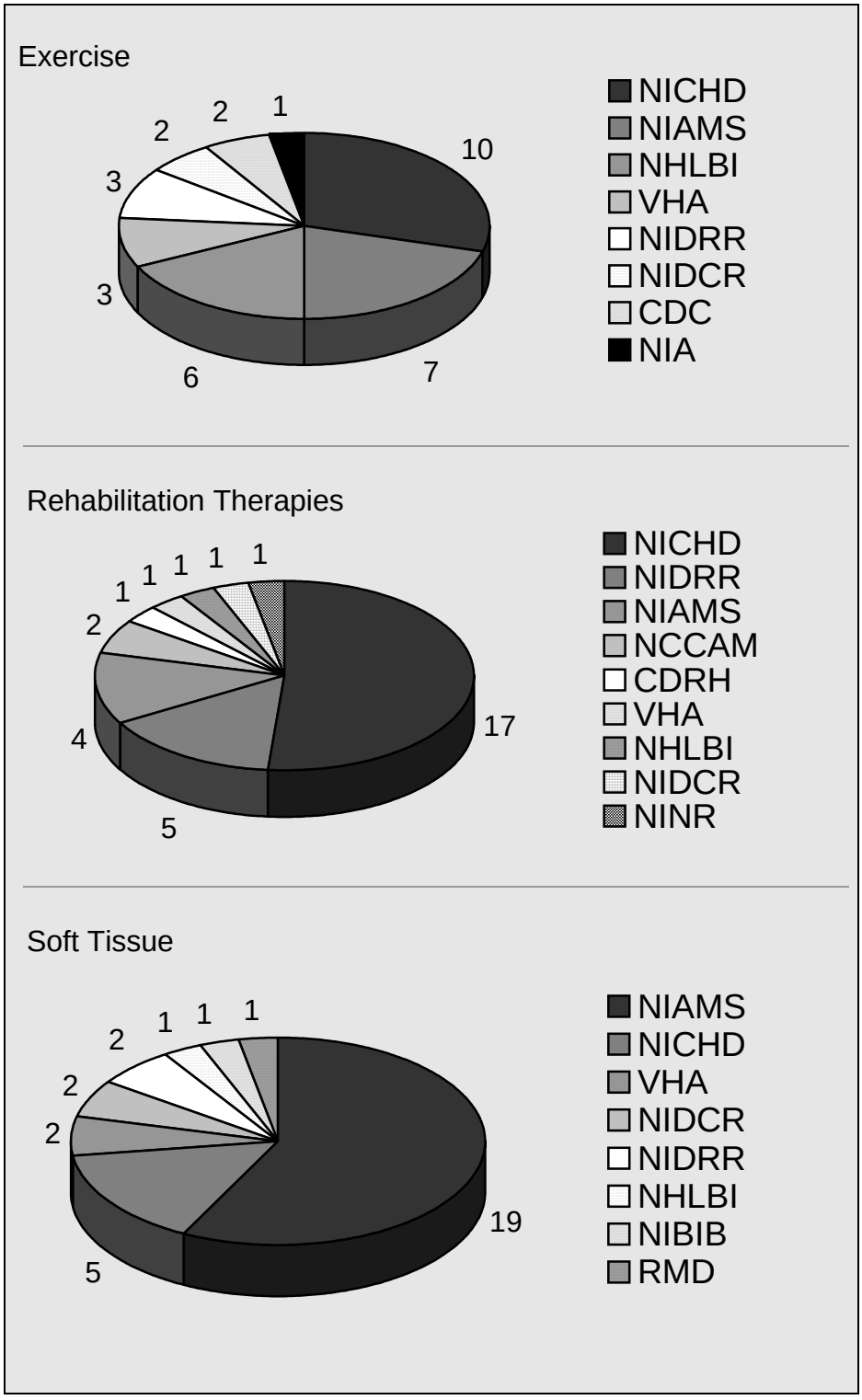


Figure 1. *(continued)*



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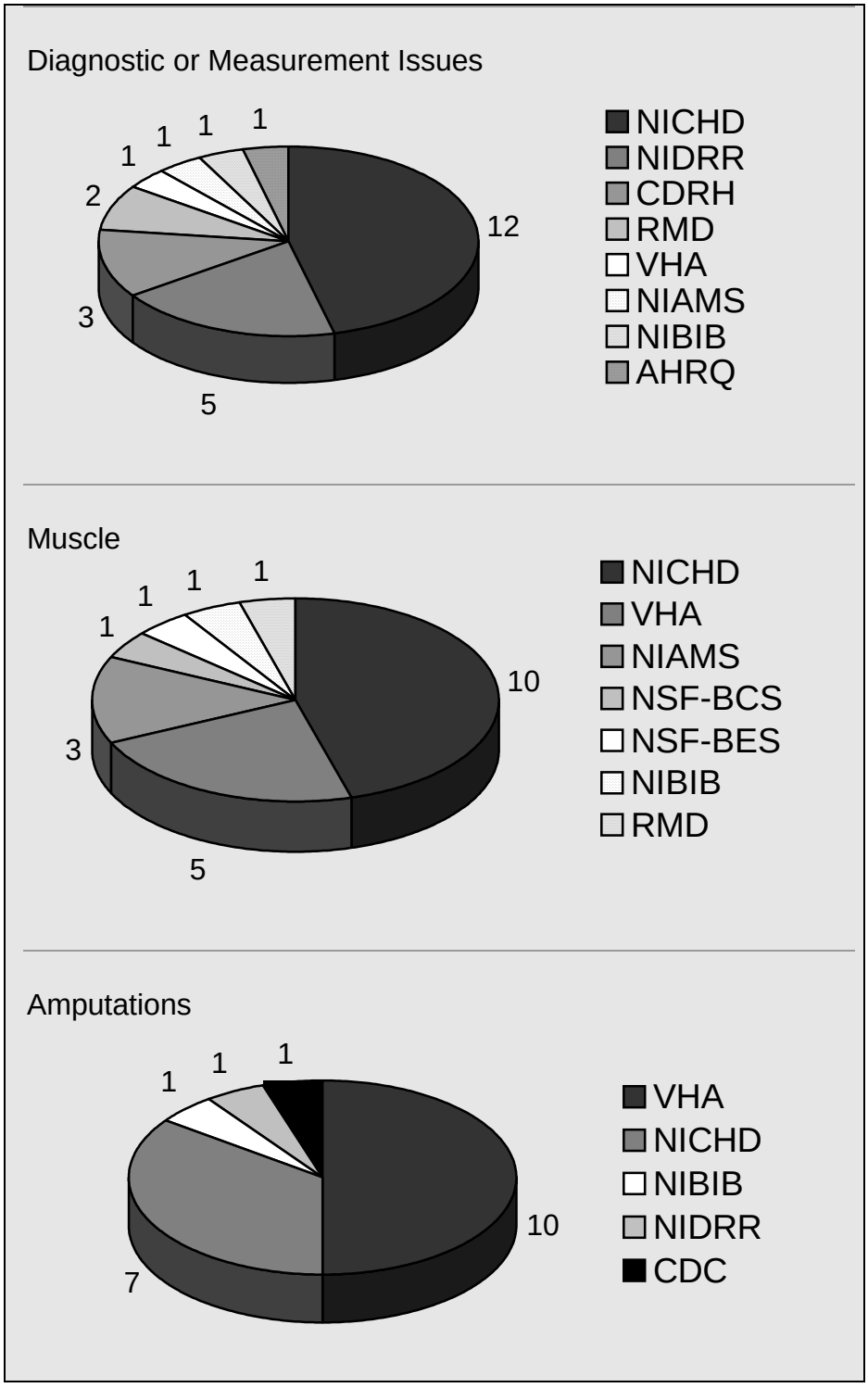

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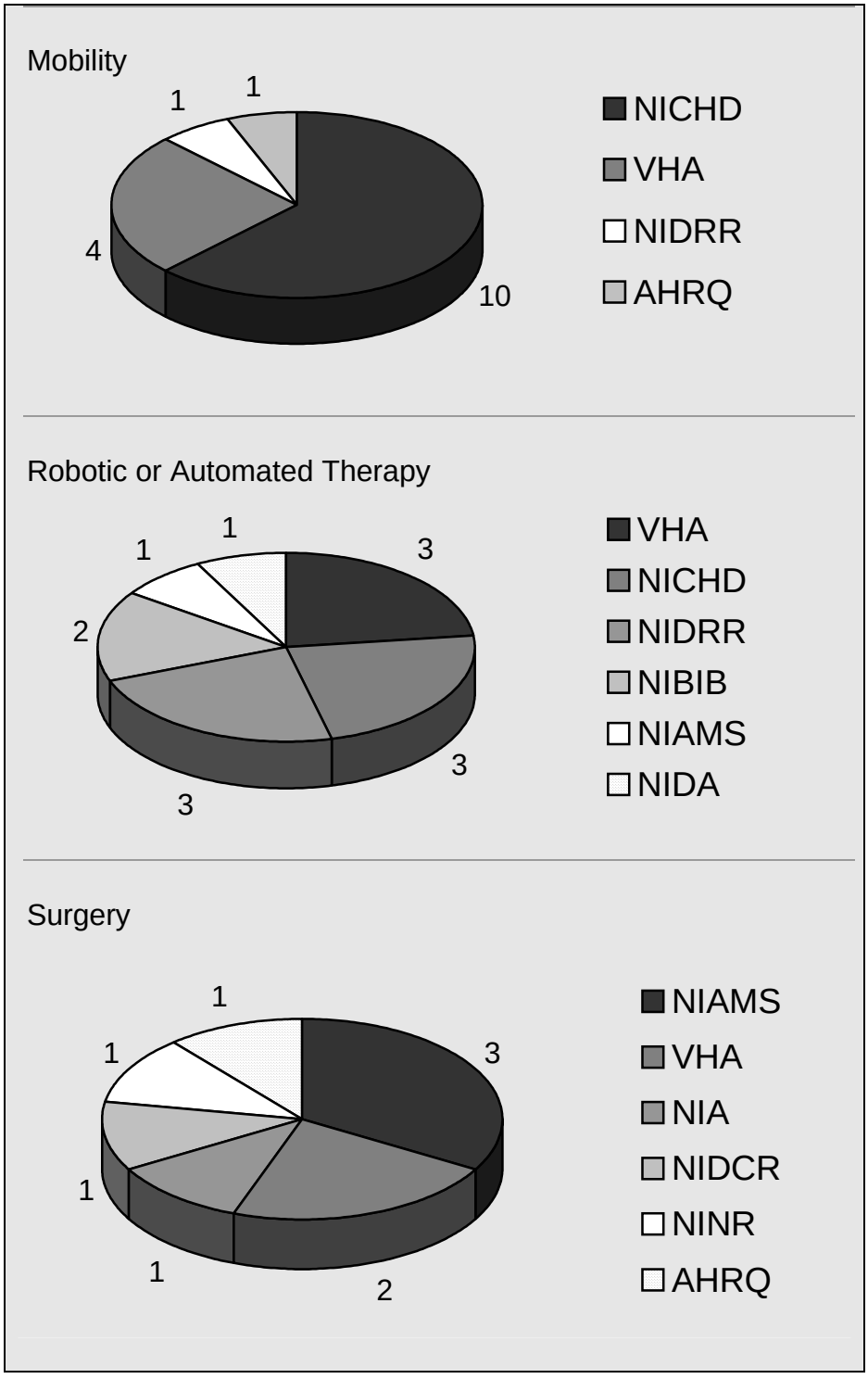

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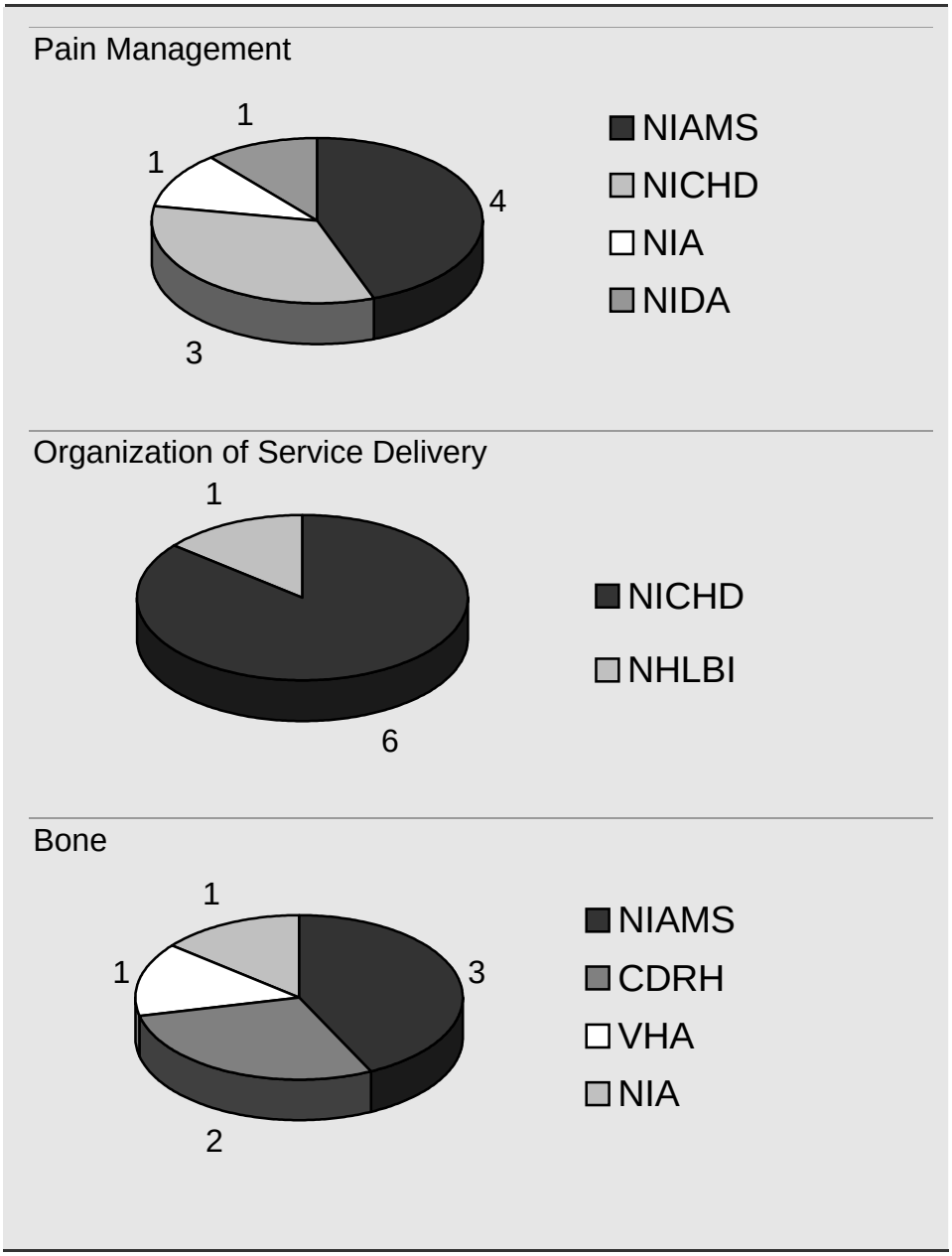
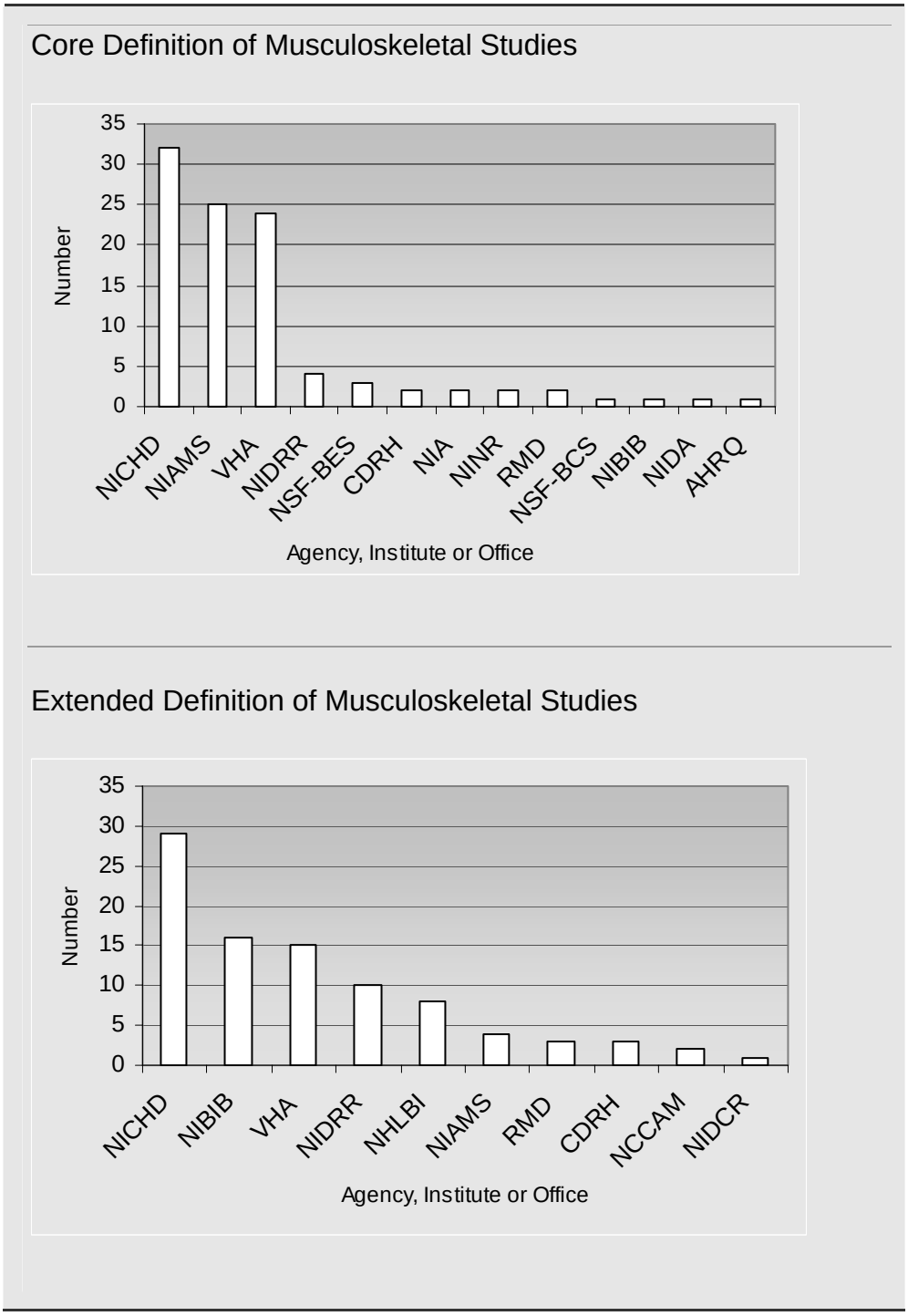


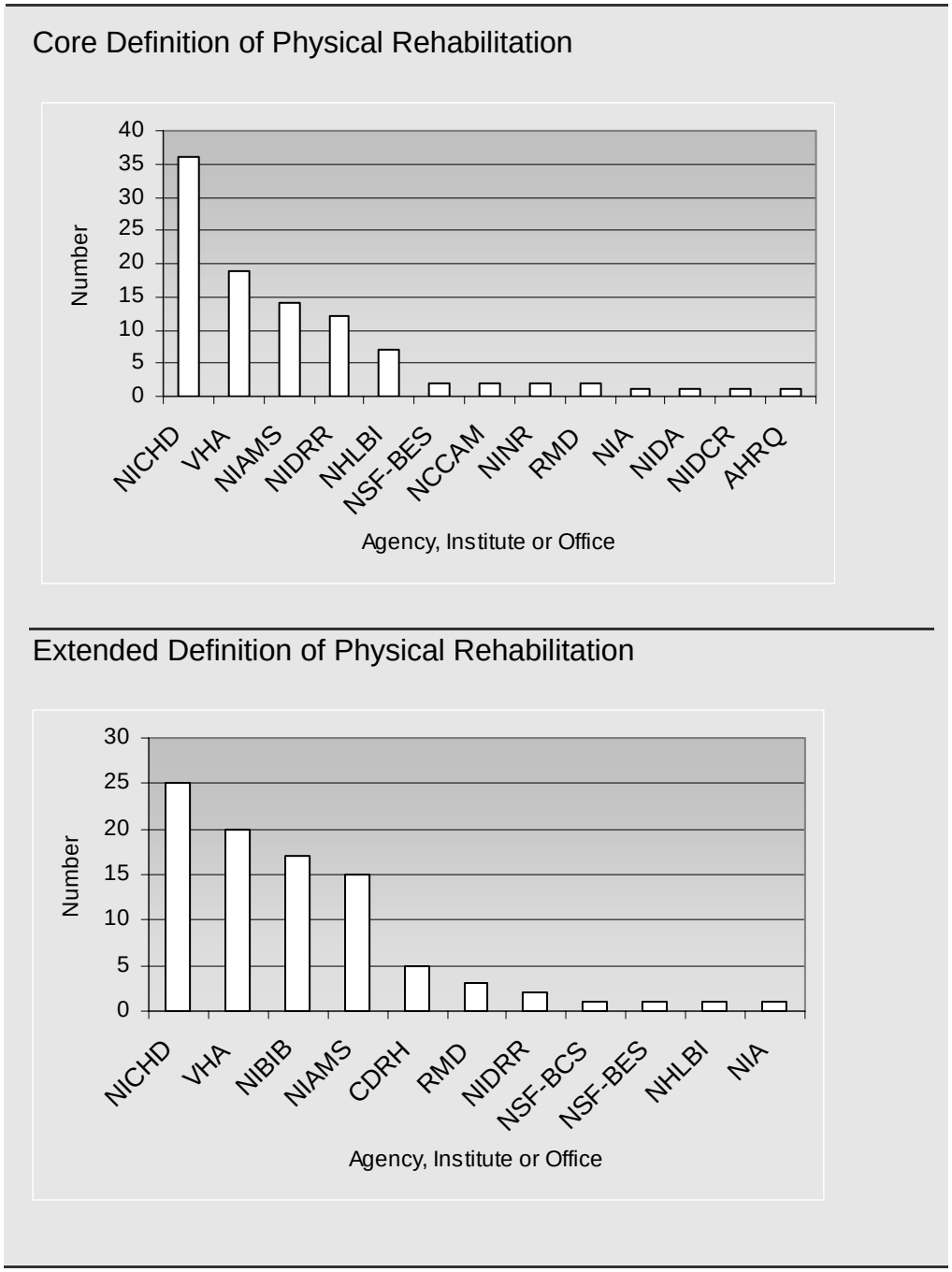
Source: ICDR Agency Survey; and CRISP database.

Figure 2. Number of federally funded musculoskeletal condition studies, by definition and agency, institute or office



Source: ICDR Agency Survey; and CRISP database.

Figure 3. Number of federally funded physical rehabilitation studies, by definition and agency, institute or office



Source: ICDR Agency Survey; and CRISP database.

Impact on Clinical Practice

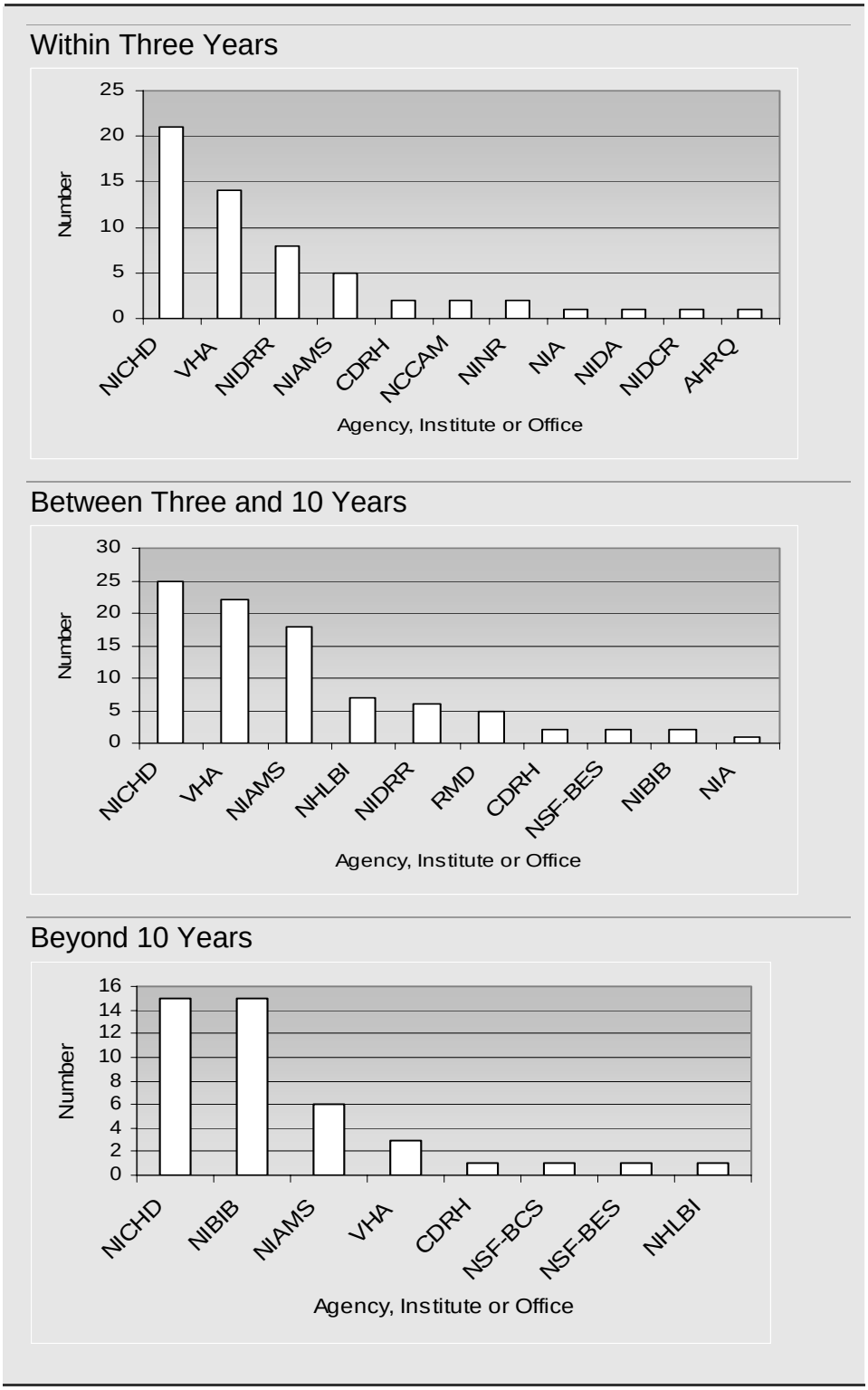
Any evaluation of a body of research should take into account the time period in which the research will have an effect on clinical practice. Based on the abstract submitted for each research study, we assigned each study to one of three arbitrary and estimated time-to-clinical practice periods: 1) effect on clinical practice within three years; 2) effect between three and 10 years; and 3) effect beyond 10 years. These subjective estimates are open to interpretation.

Following are some examples of studies and their ratings:

- A studied intervention was rated as potentially entering clinical practice within three years if:
    - It is an existing intervention but is not yet in routine clinical use (e.g., virtual reality for pain control);
    - It is an intervention in clinical use and is being further evaluated for effectiveness (e.g., gait analysis to aid in planning for orthopedic surgery); and
    - It is an intervention in clinical use and is being evaluated for use in new ways (e.g., mental imagery to reduce motor impairments in stroke patients).
- A studied intervention was rated as potentially entering clinical practice between three and 10 years if:
    - It is a diagnostic or measurement-related intervention that could lead to better evaluation of a therapy or therapies (e.g., measures of functional tasks for constraint-induced movement therapy);
    - It is a novel multidisciplinary intervention combining treatment elements in current clinical use (e.g., an interdisciplinary intervention designed to improve pain management for geriatric patients undergoing orthopedic procedures); and
    - It is a study designed to identify the factors that cause disability within a particular disease or injury, thus leading to improved treatment (e.g., the development of dynamic simulations to aid in treatment planning for gait disorders).
- A studied intervention was rated as potentially entering clinical practice beyond 10 years if:
    - It is an investigation designed to understand the basic biomechanics of a disease or injury (e.g., neurochemical modeling of postural responses);
    - It is intended to begin or continue the design process of a human-computer interface intervention (e.g., microelectromechanical system's neural clamps); and
    - It examines materials potentially useful for rehabilitation (e.g., biomimetic materials useful for rehabilitation).

The studies reviewed represented a mix of short-, mid- and long-term research-to-practice (fig.4).

Figure 4. Number of federally funded studies with an estimated time to clinical practice, by agency, institute or office



Source: ICDR Agency Survey; and CRISP database.

Capacity Building

It was not always possible to determine whether individual research projects or research programs include a capacity-building educational or facility-construction component. A small number of studies did include an explicit capacity-building function: eight NICHD studies; one NHLBI study; one VHA study; one National Science Foundation (NSF) Division of Bioengineering and Environmental Systems study; and one NSF-Division of Behavioral and Cognitive Sciences study.

Other Research Support Activities

The individual studies reported here represent only the tip of the iceberg in terms of the overall federal physical rehabilitation research effort. A number of other kinds of research support activities also contribute in a significant way to the knowledge base.

Research Programs

Research programs (table 10) are the broadest in scope of the research support activities, covering a range of topic areas. Research programs are particularly important in the federal physical rehabilitation research effort. Each program encompasses multiple researchers and many individual research studies. Each one also represents an internally coherent attempt to address either a broad topic such as the organization of service delivery or a more narrow focus such as osteoporosis. Research programs are designed to produce useful information and raise new questions so that current researchers may continue their work and new researchers may be trained.

Research programs are generally multiyear efforts funded for periods of at least three years at a time and normally renewed at the end of each grant period. They generally are located at a university with an established track record of medical research or research in other applicable fields.

NIDRR is a leader in funding and overseeing research programs at Rehabilitation Engineering Research Centers (RERCs) and Rehabilitation Research and Training Centers (RRTCs). One current RRTC, located at the National Rehabilitation Hospital/MedStar Research Institute, is the RRTC on Spinal Cord Injury: Promoting Health and Preventing Complications through Exercise. This center systematically and comprehensively addresses the role and impact of physical activity in the prevention of secondary conditions in people with spinal cord injuries.

The VHA is a leader in sponsoring programs on amputee healthcare and prosthetics research. For example, the VHA, in conjunction with the Department of Veterans Affairs (VA) and in partnership with the Department of Defense and Walter Reed Army Medical Center, is conducting a research program to investigate the immediate challenges faced by military personnel. Some specific activities being conducted through this collaborative program include the investigation of above-the-knee prostheses, a study of methods to improve the function of upper-extremity amputees, and the development of a database to support studies in improving traumatic amputee continuity-of-care.

Table 10. Number of federally funded research programs, by topic area

Topic area	Number of programs
Neurological function (normal function, injury or disease)	8
Soft tissue: joints, tendons, cartilage, ligaments	5
Robotic or automated therapy	5
Amputations	4
Exercise	4
General musculoskeletal system	4
Bones	3
Mobility	3
Cellular biology or biomechanics	2
Organization of service delivery	2
Repetitive strain injury	1
Functional electrical stimulation	1

Source: ICDR Agency Survey; and CRISP database.

Research Networks

Research networks serve a similar function to research programs. Each network must support multidisciplinary research cores, information transfers, and pilot projects, with the goal of facilitating ongoing projects and stimulating the development of future research activities in medical rehabilitation. Ultimately, the network must demonstrate the potential for increasing the quality and quantity of research applications. Although not shown in a table, two active networks were reported, both with a broad focus on rehabilitation research: the Western Medical Rehabilitation Research Network at the University of Washington, Seattle, and the Enhancing Rehabilitation Research in the South Network at the University of Virginia at Charlottesville, both funded by the NICHD.

Research Support

Research support grants (table 11) are provided to individual researchers at various points in their careers to provide support or training or to recognize outstanding researchers. Eight such grants were awarded to universities across the country.

One grant, funded by the NHLBI, supports the grantee in testing the hypothesis that exercise, in severely burned children, will improve their cardiovascular and muscle performance. Another

grant, funded by NIAMS, gives the grantee funding to gain a better long-term understanding of musculoskeletal pain and the analgesia produced by physical therapy treatments. Six grants funded by the NICHD include funding for:

- Functional outcome measurement in post-acute care settings and services;
- Plans to integrate robotic technology for diagnosis and treatment into stroke rehabilitation;
- An investigation into the biomechanical factors contributing to musculoskeletal dysfunction;
- Patient-oriented research in the area of walking (gait);
- Research on the importance of growth, nutrition and physical development on the health and quality of life of children with cerebral palsy; and
- An investigation of the interdependent relationship between the neural control of multi-joint movements and the mechanical design of the human motor system, leading to an understanding of how an injury to either of these systems compromises normal motor function.

Table 11. Number of federal research support grants, by topic area

Topic area	Number of grants
Neurological function (normal function, injury or disease)	2
Cellular biology or biomechanics	1
Robotic or automated therapy	1
Diagnostic or measurement issues	1
Pain management	1
Mobility	1
Exercise	1

Source: ICDR Agency Survey; and CRISP database.

Training Programs

Training programs (table 12) are funded through Institutional National Research Service Award grants and are overseen by and administered at colleges and universities. Their primary focus is to fund training for future rehabilitation researchers. Of the 13 training programs reported, 12 fall under the topic categories outlined in this report.

One program is funded by NIBIB and is designed to train Ph.D.s in the basic engineering and science aspects of assistive technology and in the clinical application of this technology in rehabilitation. NIAMS funds two programs, one on specifically targeted areas of rheumatology and orthopaedics and the other on autoimmunity and the biology of connective tissue disease. Ten training programs are funded by the NICHD and cover the following areas:

- Bridging the gap between science and service;
- Pathophysiological changes, impairments, functional limitations, disabilities and societal limitations of persons with disabilities;
- The rehabilitation of persons with neurologic disorders, physical impairments, disabilities and secondary complications associated with neurologic disease;
- Movement science;
- Multiple tracks (biomechanics, biostatistics/epidemiology/health services research, multiple sclerosis, stroke and pain);
- An entry-level doctorate in physical therapy, designed to train clinical physical therapists, and a Ph.D. in the biomechanics and movement sciences;
- The multidisciplinary skills needed to improve the scientific basis of medical rehabilitation and advance knowledge of the efficacy of treatment for persons with a central nervous system disease or injury;
- Interdisciplinary training in the neural bases of motor dysfunction and rehabilitation; and
- Geriatric health care and aging and in minority health and disability.

Table 12. Number of training programs, by topic area

Topic area	Number of programs
General musculoskeletal system	6
Neurological function (normal function, injury or disease)	3
Physical therapy/occupational therapy modalities	1
Soft tissue: joints, tendons, cartilage, ligament	1
Mobility	1

Source: ICDR Agency Survey; and CRISP database.

Small Business Innovation Grants (SBIR) Grants

Eleven small business grants (table 13) provide funding for rehabilitation-related small businesses to either conduct basic research or develop devices and therapies based on prior research. The grants are awarded as either Small Business Innovation Research Grants–Phase I, or Small Business Innovation Research Grants–Phase II. Phase I awards support exploration of the technical merit or feasibility of an idea or technology. Phase II awards expand Phase I results.

These grants provide a glimpse of technology that may soon be available to persons with disabilities. Current grants support research into providing a safer, less-expensive wheelchair ramp, an affordable, full-function prosthetic shoulder, and a prosthetic hand for children that is low cost and easy-to-service and repair, and provides a more natural appearance.

Table 13. Number of Small Business Innovation Research (SBIR) grants, by topic area

Topic area	Number of grants
Device design (including orthotics and prosthetics)	5
Behavioral intervention	3
Diagnostic or measurement issues	2
Robotic or automated therapy	1

Source: ICDR Agency Survey; and CRISP database.

Small Business Technology Transfer (STTR) Grants

Small Business Technology Transfer grants (table 14) serve a similar purpose to SBIR grants, but grants are given to small companies working cooperatively with nonprofit research institution partners. The five current reported STTR grants fund research designed to improve wheelchair seating, develop a new wheelchair structure that would reduce the risk of injury to wheelchair riders in motor vehicle accidents, and develop a child-friendly exercise system for children with disabilities.

Table 14. Number of Small Business Technology Transfer (STTR) grants, by topic area

Topic area	Number of grants
Mobility	2
Diagnostic or measurement issues	1
Amputations	1
Exercise	1

Source: ICDR Agency Survey; and CRISP database.

Conferences

Conferences (table 15) represent an important way to publicize research results, provide networking opportunities for researchers and build enthusiasm for research efforts. Nine conferences were reported by the agencies, institutes and offices that responded to the ICDR survey. Conference topics ranged from basic science, as in the conference on orthopaedic tissue engineering, to knowledge translation.

Table 15. Number of conferences, by topic area

Topic area	Number of conferences
General musculoskeletal system	3
Neurological function (normal function, injury or disease)	2
Robotic or automated therapy	1
Cellular biology or biomechanics	1
Mobility	1
Bone	1

Source: ICDR Agency Survey; and CRISP database.

The Evidence Base for Physical Rehabilitation Therapies

The individual research studies reported by the agencies, institutes and offices represent a body of knowledge that may lead to a solid evidence base for some physical rehabilitation therapies within three to 10 years. The reported studies represent a balance between basic musculoskeletal conditions and neuromuscular disorders. They also appear to span categories of core rehabilitation therapies as well as broader classes of therapy involving surgery, pharmacotherapy or newer techniques such as virtual reality.

The additional research support activities reported by the responding agencies, institutes and offices, such as training programs and conferences, also show promise. They span a moderately wide range of musculoskeletal topics, are reasonably geographically dispersed across the United States, and demonstrate small but useful attempts at promoting technology transfer. The research and training programs represent a valuable base through which additional research could be conducted.

Although there is cause for optimism, given the magnitude of the impact and the cost of musculoskeletal disorders, the current research effort is very small in comparison to research efforts being expended on health issues of a similar magnitude, such as heart disease.

The results of the literature search demonstrate that researchers are beginning to build and publish an evidence base in rehabilitation medicine. Although there is cause for optimism, given the magnitude of the impact and the cost of musculoskeletal disorders, the current research effort is very small in comparison to research efforts being expended on other health issues of a similar magnitude, such as heart disease. If we look at the number of funded studies by topic, we see that some topics have very few active studies: 16 for mobility, 13 for robotic or automated therapy, and nine for pain management. The additional research support activities reported by the responding agencies also show a disparity between the need for research and the amount of activity being funded.

The literature search presents the clearest case for the scarcity of physical rehabilitation research. Although we found a number of meta-analyses, several among those retrieved from the Cochrane Collaboration noted significant methodological weaknesses in the quality of the studies examined. The number of the RCTs in the published literature is very small in comparison to the number of the RCTs available for other body systems and health conditions.

Nationally accepted clinical guidelines focused on physical rehabilitation therapies, as opposed to general reviews of musculoskeletal disorders, are almost nonexistent. In a Consensus Statement on Total Knee Replacement (TKR), members of the NIH Consensus Development Panel (U.S. Department of Health and Human Services 2003) noted that "the use of rehabilitation services is perhaps the most understudied aspect of the perioperative management of TKR patients."

Strengthening Exercises for Osteoarthritis

It's 8 a.m. My muscles loosen as I soak up the spring sun through windows at the university's gymnasium. I sit on a mat and bend my torso forward, stretching gently. After five to 10 minutes, I settle in on one of the weight machines and push with my feet against the cold, creaking metal, working my quadriceps. I have knee osteoarthritis, and once again I'm astonished I can actually lift the weights with my legs. I complete 10 repetitions and then move to the exercise bicycle, where I pedal for 20 minutes. This is my time to chat with friends young and old, which keeps me in step with the times.

At 9 a.m., my long-time friends and I walk to the nearby coffee shop. Just four months ago, it took me at least an hour every morning to walk without limping. My wife was always hovering, ready to catch me if I stumbled. She had given up walks with her friends and going to plays. Both of our lives were limited by my knee osteoarthritis. I always kept my pain medication handy and worried about the cost of the medicine each time I took the cap off the bottle. I missed attending the university football games because I couldn't climb the bleacher stairs.

One day my doctor said a research study found that aerobic activity and quadriceps strengthening exercises could reduce pain and disability from knee osteoarthritis. So I worked with a physical therapist on the proper exercises. Now I go to the gym four days a week, and I have gradually increased my activity. I take pain medication only if I've had a particularly strenuous day, and I make it to the second tier of the football stadium bleachers. I've also lost eight pounds!

–Carlos, age 78

Section 3: Opportunities for Future Research

Several factors must be taken into account when planning future research efforts. First, it is important to have an understanding of the amount and variety of the existing research, because research normally builds on previous efforts. This report provides such an overview. Second, it is necessary to consider the need for future research—What will musculoskeletal conditions look like in five, 10 or 50 years? Who will make up the U.S. population in the future? What will the health care needs be?—and the potential advancements in scientific methods to appreciate what is possible.

Third, it is important to examine how to structure the overall research effort to most effectively advance the field: Will the same agencies, institutes and offices fund studies through the same kinds of funding mechanisms, or should a different research structure be designed? How will the challenges to researchers (discussed later in this section) be overcome in order to advance the field of physical rehabilitation?

Finally, and perhaps most important, is to have a firm sense of the potential worth of physical rehabilitation research in promoting sound, effective clinical practice. This sense was conveyed during an advisory committee meeting when the discussion turned to the role of physical rehabilitation in health care. Practitioners with experience in the field noted that often in cases of musculoskeletal conditions, pharmacotherapy is the first line of treatment offered, and rehabilitation is seen as a last resort. The group agreed that rehabilitative techniques such as exercise should instead be considered as first-line treatments, either alone or in conjunction with pharmacotherapy. Initial rehabilitative therapy, if successful, could reduce the need for drug therapy, thus reducing costs and avoiding potentially harmful side effects.

Population and disability trends will shape the need for continuing rehabilitation research.

Assessment of Future Research Needs

Population and disability trends will shape the need for continuing rehabilitation research. The ICDR has identified the following demographic, treatment and health services topic areas in which increased research funding will be needed:

Demographics

- Healthy aging;
- Obesity and other emerging sources of disability;
- Athletic and overuse injuries;
- Civilian and military injury or disease resulting from terrorism;
- Underserved groups; and
- Rural residents.

Care Delivery

- Delivery of services (supply and demand);
- Continuity of care versus care based on acute episodes;
- Communication and decisionmaking among healthcare providers and patients;
- Person-centered care; and
- Aging caregivers.

Biomechanics

- Causes of disability;
- Natural history of disabling conditions; and
- Mechanisms of repair.

Diagnosis and Assessment

- Diagnosis of disability;
- Measurement of disability;
- Measurement of fatigue;
- Assessment of rehabilitation interventions; and
- Understanding how to assess quality of life.

Physical Interventions

- Prevention and treatment of primary and secondary disabilities;
- Multiple morbidities;
- Whole-body function;
- Whole-body motion;
- Conservative management treatments (i.e., core physical therapy interventions);
- Movement-based rehabilitation interventions, especially therapeutic exercise;
- Occupational therapy interventions such as performance enhancement for ADLs;
- Postsurgical rehabilitation;
- Dosage (optimal frequency, intensity and duration of an intervention);
- Timing of interventions;
- Interactive effect of multiple interventions and combined interventions; and
- Intervention confounders.

Psychiatric and Emotional Interventions

- Coping and self-efficacy;
- Psychological aspects of rehabilitation;

- Environmental adaptation, including independent living, community integration, employment and schools; and
- Understanding behavior as it relates to participation in rehabilitation.

Given the number of areas identified as requiring increased funding, it will most likely be necessary to establish priority areas for funding purposes. This will require consultation with experts in the field. Some valid approaches to assigning priority to topic areas include:

- Level of incidence and prevalence and severity of the disability in the U.S. population;
- Parity of service to rural versus urban populations;
- Parity of service to traditionally underserved groups;
- Cost per individual to offer rehabilitative services;
- Likelihood of a cure for the disorder;
- Technological breakthroughs, such as a "smart" house (in which computers throughout the house operate appliances and send and receive information); and
- Level of fit with other national priorities.

Assessment of Future Scientific Opportunities

The "Future Directions for the NCMRR" section of the National Center for Medical Rehabilitation Research (NCMRR) publication, *National Center for Medical Rehabilitation Research: Report to the National Advisory Child Health and Human Development Council (September 2001)*, lists several areas where rehabilitation advance are expected in coming years:

- Functional neuroimaging;
- Understanding of the nervous system, especially its plasticity;
- Tissue and cellular engineering;
- Neural prosthesis;
- Nanotechnology and materials science at the molecular level;
- Simulation and modeling techniques;
- Computerized dynamic assessment of outcomes; and
- Development of assistive technologies to improve independence and safety in self-care to allow increased participation in the community.

If these occur as anticipated, they may lead to specific advances that could make a major difference in the next five to 10 years, such as: telehealth (the virtual home visit); intelligent garments; motion-induced therapies; a better understanding of factors enhancing adoption of new behaviors; robotic devices to replace scarce human resources; the synergy in combined treatments, such as stem-cell therapy combined with exercise; and better timing of interventions.

Alternative Study Designs

Although the RCTs are accepted as the gold standard for quality of evidence, there are a number of reasons why the RCTs alone may not be sufficient to provide the evidence base needed to evaluate all existing or proposed clinical interventions, particularly in the area of physical rehabilitation.

As part of the growing effort to develop new ways of providing reliable evidence for the value of health care interventions, the Agency for Healthcare Research and Quality (AHRQ) joined the ICDR, the NCMRR, the Institute for Clinical Outcomes Research, Vanderbilt University, and the Pharmaceutical Research and Manufacturers of America to hold a conference on "Alternative Study Designs for Evidence-Based Practice: Harnessing Natural Variation for Effectiveness Research" in October 2005. At that conference, Carolyn M. Clancy, Director of the AHRQ, discussed the need to widen the scope of acceptable research techniques beyond the RCT (Clancy 2005). In her presentation, "Research and Evaluation Designs for Clinical Effectiveness Studies," Dr. Clancy noted that the challenges to the RCTs stemmed from elements often integral to physical rehabilitation practice, such as rare conditions, multiple morbidities, complex interventions, and the need to take into account the setting in which the intervention occurs.

Three alternative study designs were reviewed: analyses of existing administrative databases; quasi-experimental designs such as cohort studies or time series; and the clinical practice improvement (CPI) study design, an observational study design whose measurements encompass a comprehensive view of the care management process. Each of these alternatives takes advantage of advances in computer-based statistical analysis to "harness the full power of multivariate statistics in which many variables can be considered simultaneously and covariates can be identified and neutralized to evaluate intervention effects" (Horn et al. 2005).
A small number of the CPI studies have begun to be published, each demonstrating a useful outcome. Horn et al. (2005) listed a number of studies on: mechanisms for reducing the rate of postoperative wound infection following abdominal surgery; techniques for lowering the incidence of pressure ulcers in nursing home residents; unintended outcomes of drug formulary limitations in the elderly; and outcomes of including regularly scheduled meetings with providers for patients with diabetes. They noted that the RCTs and alternative designs such as the CPI should be seen as complementary, rather than mutually exclusive, and that "practice effects of RCTs can be tested in the CPI studies and the CPI can be a progenitor of new RCTs."

Alternative study designs such as these show great promise for advancing the goal of obtaining "more timely, valid, convincing and practical information on what works" (Clancy 2005). Such research techniques could be particularly relevant to physical rehabilitation research because they could support the multilevel, multifactor research needed to investigate questions of functioning and impairment discussed in section 4 of this report. Additionally, such techniques could incorporate the evaluation of the environmental and policy contexts in which rehabilitation interventions take place.

Research Program Structure

Even a very high volume of research may not lead to many useful results if it is not coordinated throughout the entire process, from initial research to clinical practice. For example, in an uncoordinated effort, a large number of studies may focus on one topic, leaving other topics under-researched. Or several researchers may perform studies that are unnecessarily duplicative, wasting time and resources.

Continued development of an overall federal rehabilitation research program structure will strengthen the research effort in this area by encouraging coordination of efforts, providing a way for researchers to be aware of ongoing studies, and providing a forum for researchers to plan future collaborative activities.

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Three current organizational models exist on which the federal disability research structure could be based: the International Classification of Functioning, Disability and Health (ICF) Model; the IOM Model (enabling/disabling process described in *Enabling America: Assessing the Role of Rehabilitation Science and Engineering*), and *NIDRR's Long-Range Plan for Fiscal Years 1999-2004* Model.

The ICF Model

The ICF Model is structured around the following broad components (World Health Organization 2001):

- Body functions and structure;
- Activities (an individual's tasks and actions) and participation (involvement in a life situation); and
- Environmental factors.

Functioning and disability are viewed as a complex interaction between the health condition of an individual, and the contextual factors of the environment and personal factors. The environment includes the home, school, place of work and recreational settings. The picture produced by this combination of factors and dimensions is of the person in his or her world. The classification treats these dimensions as interactive and dynamic rather than linear or static. It allows for an assessment of the degree of disability, although it is not a measurement instrument. It is applicable to all people, whatever their health conditions. The ICF language is neutral as to etiology, placing the emphasis on function rather than on condition or disease. It also is carefully designed to be relevant across cultures as well as age groups and genders, making it highly appropriate for heterogeneous populations.

The IOM Model

The IOM Model attempts to show "how biological, environmental (physical and social), and lifestyle/behavioral factors are involved in reversing the disabling process, i.e., rehabilitation, or the enabling process" (Brandt and Pope 1997, 6). The model is based on four concepts:

- *Pathology*: Interruption or interference of normal bodily processes or structures.
- *Impairment*: Loss and/or abnormality of mental, emotional, physiological, or anatomical structure or function: includes all losses or abnormalities, not just those attributable to active pathology; also includes pain.
- *Functional limitation*: Restriction or lack of ability to perform an action or activity in the manner or within the range considered normal that results from impairment.
- *No disabling condition:* Indicates that complete rehabilitation is feasible.

(Brandt and Pope 1997, 6)

NIDRR's Long-Range Plan Model

The *NIDRR Long-Range Plan for Fiscal Years 1999-2004* provides a useful perspective on foci for research inquiries as well as requirements for research management. It builds on aspects of the ICF and IOM Models and concludes that:

> What is needed are studies of the dynamic interplay between person and environment; of the adapting process, by the society as well as by the individual; and of the adaptive changes that occur during a person's lifespan. The aging of the disabled population in conjunction with quality of life issues dictates a particular focus on prevention and alleviation of secondary disabilities and co-existing conditions and on health maintenance over the lifespan. Research must focus on the development and evaluation of environmental options in the built environment and the communications environment, including such approaches as universal design, modular design, and assistive technology that enable individuals with disabilities and society to select the most appropriate means to accommodate or alleviate limitations. (U.S. Department of Education 1999, 45752)

The NIDRR's plan also calls for researchers to understand "the public policy context in which disability is addressed, ignored, or exacerbated" (U.S. Department of Education 1999, 45752).

Each of these models could form a framework for classifying, organizing and planning federal research efforts. They could be especially useful in situations calling for interdisciplinary or cross-disciplinary research (which should include experts in basic science, clinical research, health services research and social research). For example, basic biomechanical studies could be organized into a pathology track; the results of these studies could be used as the basis for designing further investigations in an impairment track.

Continuing Challenges

Both existing and new challenges to the physical rehabilitation research effort will need to be addressed in order to advance the field. Listed below, these include demographic and health challenges, fiscal challenges, technical challenges and organizational challenges.

Demographic and health challenges

- Aging population;
- Sedentary population;
- Increasing rates of conditions (such as obesity) that may lead to disability; and
- Increasing potential for military or civilian injuries resulting from terrorism leading to disability.

Fiscal challenges

- Continued competition for research funds across all areas of research, including health, employment, community integration, independent living and vocational rehabilitation;
- Need for increased research capacity and funding for fellowships;
- Need for improved research infrastructure; and
- Need for more investment in technology translation.

Technical challenges

- Need to develop alternative methodologic approaches to rehabilitation research for situations where the RCTs are not feasible;
- Need for new instruments and techniques to study disability in the natural environment, not just in the laboratory or clinical environment;
- Need for improved outcome measures, including consideration of patients' preferences and values; and
- Need for improved study design methods, including:
    - Identifying an appropriate, reproducible intervention, including dose and frequency;
    - Identifying appropriate control groups;
    - Randomizing subjects to treatment groups in an unbiased manner;
    - Maintaining investigator and subject compliance to the protocol;
    - Reducing bias by blinding subjects and investigators to group assignment;
    - Identifying and employing appropriately validated and standardized outcome measures; and
    - Employing appropriate analyses, including the intent-to-treat paradigm.

Organizational challenges

- Protected research time for academically based scientists with clinical responsibilities;
- Mentorship of research fellows; and
- Ability to establish an interdisciplinary focus for research.

Nerve Gliding Exercises for Carpal Tunnel Syndrome

I had been writing feature articles for a nature magazine for almost 10 years, often using the computer for five hours a day, five days a week. About six months ago, I started to feel some tingling and occasional numbness in my right wrist. I started to take more frequent breaks from the computer and shake my hand for relief. After a few weeks it became painful to type and even to pick up my two young children. When the pain started waking me up at night, I became desperate. My primary care specialist told me I had carpal tunnel syndrome and presented surgical and nonsurgical approaches.

In searching Web sites, I learned that even though carpal tunnel release surgery is one of the most common hand and wrist operations performed, there is risk of surgical injuries and postoperative complications such as nerve injury, infection and tendon injury. But there is evidence that more conservative treatment can effectively manage symptoms.

I chose the nonsurgical approach. I started doing nerve gliding exercises, which involve bending and straightening the wrist, fingers and thumb three to five times a day. After four weeks, I slept through the night, held my children without wincing, decreased the amount of ibuprofen I took, and started typing again without pain.

–Isabella, age 38

Section 4: Coordinating Federal Research and Reaching National Health Goals

Healthy People 2010, an effort managed by the Office of Disease Prevention and Health Promotion, at the HHS, sets a series of goals for the U.S. population over the coming years. Musculoskeletal conditions are addressed in two areas of the plan: area 2: "Arthritis, Osteoporosis, and Chronic Back Conditions," and area 6: "Disability and Secondary Conditions" (U.S. Department of Health and Human Services 2000).

The national health goal identified in area 2 is to "Prevent illness and disability related to arthritis and other rheumatic conditions, osteoporosis, and chronic back conditions." The overarching goal presented in area 6 is to "Promote the health of people with disabilities, prevent secondary conditions, and eliminate disparities between people with and without disabilities in the U.S. population." A well-executed, effective research program in the prevention, causes and treatment of musculoskeletal disorders will make a significant contribution to these overall long-term health goals of the United States.

Individuals with limitations in their activities of daily living consume far more medical resources per capita than their non-disabled counterparts. Rehabilitation has the potential to not only return disabled individuals to their communities but also to reduce their risk of recurrent illness.

The ICDR has continued to foster collaboration among agencies, institutes and offices funding rehabilitation research. Agencies, institutes and offices have been encouraged to review their mission statements to minimize overlap and maximize synergy between agency, institute, or office missions. This process is fostered by regular reports and discussion at ICDR meetings as well as by electronic communication. For example, extensive discussion among NIDRR, the NIH, the VA and the HHS' Office on Disabilities preceded development of the NIDRR priorities for recompetition of the Spinal Cord Injury Model Systems grants. Development of a "one-stop shop" for information about federally sponsored rehabilitation research is proceeding.

The ICDR and its member agencies, institutes and offices are mindful of the complexities and budgetary challenges facing the Congress in determining appropriations for federally sponsored research. Recommendations for statutory changes to improve the organization of disability and rehabilitation research support in the federal government have been addressed in previous reports. One recommendation was to create a new agency for disability and rehabilitation research within the HHS (Brandt and Pope 1997) and a second was to establish an independent institute or center within the NIH (Verville and DeLisa 2003)

These two recommendations arose from efforts heavily involving the private sector, which took a comprehensive and broad view of the field of disability and rehabilitation research, rather than a narrow focus on physical rehabilitation. The amount of time and expertise devoted to developing these recommendations was significantly larger than the capabilities of the ICDR in this regard.

In view of this, the ICDR draws the attention of Congress to these existing recommendations without further comment.

The ICDR further wishes to draw the attention of Congress to the overwhelming proportion of medical costs due to chronic disease in the United States. Individuals with limitations in their activities of daily living consume far more medical resources per capita than their nondisabled counterparts. Rehabilitation has the potential to not only return disabled individuals to their communities, but also to reduce their risk of recurrent illness. To achieve this goal, much basic and applied research in physical rehabilitation will be required.

Appendix A:
ICDR Overview

Section 203 of the *Rehabilitation Act of 1973*, as amended, establishes the ICDR "to promote coordination and cooperation among federal departments and agencies conducting rehabilitation research programs, including programs relating to assistive technology research and research that incorporates the principles of universal design." The act also specifies the work of the ICDR:

> After receiving input from targeted individuals, the Committee shall identify, assess, and seek to coordinate all federal programs, activities and projects, and plans for such programs, activities, and projects with respect to the conduct of research (including assistive technology and research that incorporates the principles of universal design) related to rehabilitation of individuals with disabilities.

The ICDR is required to submit an annual report to the president and to appropriate committees of Congress with recommendations for coordinating policy and developing objectives and priorities for all federal agencies related to disability and rehabilitation research.

The director of NIDRR is designated to chair the ICDR. Statutory members include:

- Commissioner of the Rehabilitation Services Administration;
- Assistant Secretary of the Office of Special Education and Rehabilitative Services;
- Secretary of Education;
- Secretary of Veterans Affairs;
- Director of the NIH;
- Director of the National Institute of Mental Health (NIMH);
- Administrator of the National Aeronautics and Space Administration;
- Secretary of Transportation;
- Assistant Secretary of the Interior for Indian Affairs;
- Director of the Indian Health Service; and
- Director of the National Science Foundation (NSF).

Many other federal agencies play significant roles in disability and rehabilitation research, either by funding research or by being consumers of the resulting research. By invitation of the chair, other agencies regularly participate on the ICDR either in the full committee or on its various subcommittees.

Appendix B:
ICDR Agency Survey

Senate Report 108-345 – Departments of Labor, Health and Human Services, and Education, and Related Agencies Appropriation Bill, 2005, in appropriating funds to the National Institute on Disability and Rehabilitation Research (NIDRR), states:

> The Committee acknowledges that physical rehabilitation services are essential to the functional status and independence of individuals, particularly those dealing with musculoskeletal conditions. The Committee directs the Interagency Committee on Disability Research to report on the existing, agency-wide research activities relating to physical rehabilitation, opportunities for future physical rehabilitation research, and recommendations on how physical rehabilitation research can be enhanced within the departments and agencies, including suggestions for those areas that need to be addressed through statutory changes.

The ICDR is responding to this directive, in part, by surveying federal agencies on their current research activities in the area of physical rehabilitation, particularly for musculoskeletal disorders. The results of this survey will be collected in a Compendium and reported to the Senate after a review by the full ICDR membership.

We ask your help in identifying research activities funded by your Agency on physical rehabilitation, particularly for musculoskeletal disorders. Please also include any recommendations your Agency may have for enhancing physical rehabilitation research. We ask that you respond to this survey by Friday, May 20, 2005. If you have any questions about this survey, please contact Dr. Diane Boyd, who is assisting the ICDR with this survey, at dboyd@cessi.net or (703) 448-6155, ext. 235. Thank you for your assistance with this effort.

Instructions

Please list and describe each funded research grant that was active in FY 2005. Activities may be directly related to research, such as "coordinated programs of research," research centers, centers of excellence, training centers, utilization centers, field-initiated projects, research and development projects, research training projects, model systems of research, rehabilitation engineering research, or fellowships. We are asking that Agencies use the following format to report. However, if your Agency has a very large number of research projects, and you would like to discuss responding in a different format, please contact Dr. Boyd.

Please report one research activity per matrix (copy and paste the matrix as many times as needed).

Title of project or activity	
Grant #	
Name and contact information for Principal Investigator	
Please provide a link to the Website URL where an abstract or description of the project may be obtained. If no online information is available, please provide a brief project description here.	
Category of project or activity (such as Center of Excellence, SBIR, etc.)	
Dollar amount funded	
Period of performance	
Please include any additional comments here	

After you have identified your current research activities, please answer the questions below:

Do you fund any capacity-building projects? (i.e. activity designed to promote the training of rehabilitation research personnel). If yes, please describe:

Does your Agency conduct research jointly with any other Agencies or organizations? If yes, please describe:

What are your Agency's current overall rehabilitation research priorities?

What specific topic areas would you recommend for further research?

Can you recommend opportunities for interagency cooperation to achieve progress in these topic areas?

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