Considerations on Research Priorities in Physical and Rehabilitation Medicine

Walter R. Frontera, MD, PhD[1]

Significant attention has been given recently to the topic of research in the field of Physical and Rehabilitation Medicine (PRM) in professional organizations, national and international scientific meetings and in peer-reviewed journals. This discussion has focused on the general importance and relevance of scientific research for society, the need to develop a stronger scientific base for the practice of PRM, the strategies needed to accomplish this goal, and the agenda and strategic plan that will guide our scientific efforts. It is well known that many professional disciplines and scientific fields are an integral part of the practice of rehabilitation. Although my comments in this article may relate more to the biomedical aspects of the practice and the medical specialty of PRM, they should be considered in the context of the multi- and interdisciplinary nature that characterizes the practice of rehabilitation. Moreover, this article is a general overview and not a detailed discussion of the topic.

Research: a required activity

According to Nobel Laureate Peter Medawar[1], scientific research is an exploratory activity of which the purpose is to come to a better understanding of the natural world. The results of this activity represent knowledge in which we have much more confidence than we have in opinion, hearsay, and belief because it has been achieved more systematically and objectively using the scientific method (including observation, experiment, and reasoning by deduction and induction). Those who practice the medical specialty of PRM must have confidence in the knowledge base of the field and the interpretation and understanding of fundamental concepts, such as function, because these concepts define who we are and what we do. Further, those persons with disabilities who receive clinical rehabilitation services and their relatives must also have trust in what we do and in our recommendations to them. Scientific research is an important way (albeit not the only way) of achieving that confidence and trust.

Moreover, scientific research is essential for the development of any profession (including all medical specialties). By definition, a profession is a calling requiring specialized knowledge and long and intensive instruction in skills and methods as well as in the scientific, historical, or scholarly principles underlying such skills and methods[2]. Therefore, to a significant degree, the development of a profession will depend on the existence of a knowledge base that is unique, obtained with reliable methods, amenable to testing, and supported by evidence. It is important for the future of PRM to observe these rules.

Research is the activity that will allow us to find and understand the essential causes and solutions to the clinical problems that result in functional loss, that limit individual activity, and restrict participation in our patients. In PRM, as well as in rehabilitation in general, the identification of research problems in need of a solution is a rather simple task because of the breadth of clinical issues associated with function and disability and the many accepted gaps in knowledge in the field. However, in order to conduct research that helps to fill the gaps in knowledge, two elements are crucial: "one must have an insight into which problems are ripe for resolution, and one must then have the craft - or invent it - to solve the problem one has had the audacity to recognize as solvable"[3]. Rehabilitation clinicians, scientists, and persons with disabilities must come together to identify both.

Why research in PRM

The survival of the medical specialty of PRM (and other professions related to rehabilitation) and the relevance of its contribution to society will depend, to a significant degree, on the performance of research and the translation of research findings into practices that become standards of clinical services in hospitals, ambulatory clinics, and health care systems. In other words, it is an important goal to use basic science observations and discoveries to design new treatments that all patients, health care providers, and health care systems can use to enhance quality of life for all human beings.

There are many general and specific reasons that justify

1 Dean, Faculty of Medicine
Professor, Departments of Physical Medicine and Rehabilitation and Physiology
University of Puerto Rico
Editor-in-Chief
American Journal of Physical Medicine and Rehabilitation
Recinto de Ciencias Médicas
Oficina A 880
P.O. Box 365067
San Juan, Puerto Rico

the conduct of research in the field of PRM. Among other things, we need to conduct research in PRM to achieve a better understanding of rehabilitation related issues and problems, to inform our clinical decisions and therapeutic interventions, to design better and more effective rehabilitation programs, to design and construct health delivery systems that provide continuity of services after the acute accident or medical events, to influence health (and reimbursement) policy, and to contribute new knowledge that applies outside of our field and impacts health care in general. Governments, non-governmental organizations, and private institutions should invest in research in general because it is important to reduce morbidity and mortality from common diseases such as cancer and heart disease. Further, investments in PRM and rehabilitation research may also reduce the burden of chronic disability, augment healthy and functional life expectancy, and enhance the quality of life of all individuals.

During the last 50 years we have seen dramatic advances in science and medicine in areas such as genetics, stem cell biology, tissue engineering, robotics, nanotechnology, pharmacogenomics, and many others. Because of the fundamental nature of these developments, all of these areas have potential applications in PRM and rehabilitation. How can we in PRM (and in rehabilitation in general) not take advantage of these discoveries and innovations? How can we afford not to be part of this scientific revolution? I suggest that we can be part of this transformation without surrendering to reductionism; an approach that may be contrary to the philosophical underpinnings of rehabilitation. Rehabilitation research and stem cell research should not be considered mutually exclusive but rather part of a continuum that can help us achieve rehabilitation's ultimate goals.

At least two important priorities must be considered by all interested in the future of the field: building research capacity and defining a research agenda. These priorities require discussions at the level of individual institutions but also among colleagues working in different settings and countries. The strength of our research efforts will depend on our ability to have an open discussion, foster collaborations, promote a healthy exchange of ideas and results, and harmonize research strategic plans. Although many individuals can and will make significant contributions to our knowledge base, a team effort is not only desirable but needed.

Research Capacity

Let's consider first the challenge of building research capacity. According to Trostle[4], capacity building is a general term for a process of individual & institutional development which leads to higher levels of skills & greater ability to perform useful research. In many respects, I would like to argue that this applies not only to institutions but also to professions, medical specialties, and scientific fields of interest. To enhance research capacity at any and all of the four levels, we need a critical mass of investigators with access to adequate resources using a team approach to conduct research that will influence clinical practice.

Building research capacity depends on several factors: ①the recruitment and retention of junior and senior talented investigators to the field and the development of training programs for interested students at different levels; ② the development of a research infrastructure (space, equipment, etc.) together with an institutional culture and environment that fosters, values, and rewards scientific inquiry; ③ the provision of adequate funding at different stages of the career of an investigator to support the effort; ④ the establishment of research collaborations and partnerships with colleagues in PRM, other scientific fields, and members of the community; ⑤the development and implementation of an evaluation system with appropriate metrics to document the outcomes of the effort and to facilitate strategic decisions[5]. Given the interdependence of these elements, all of the above must be implemented simultaneously and in a coordinated manner. In the next few paragraphs I will comment briefly on all the five elements of research capacity mentioned above.

It is clear that in order to produce new knowledge, a pool of well-qualified researchers must be identified. In all fields of knowledge the training, mentoring, and placing of new investigators is essential to accomplish this goal. These training efforts can target medical students, residents in different medical disciplines, graduate students in the biomedical and social sciences, and junior faculty starting their research or clinical activity. Among the medical specialties the main challenge is that many clinicians are not interested in research. In fact, the current number of physician-scientist appears to be dwindling significantly[6]. Another strategy to strengthen the pool of investigators is to recruit and retain established and experienced researchers. In a field like PRM without a long-standing tradition of research it may not be easy to find enough well-qualified senior investigators trained in rehabilitation disciplines. Thus, it makes sense to attract successful investigators from other fields and to encourage them to tackle problems in PRM using their expertise, technical skills, and enthusiasm to address interesting new challenges.

In addition to conducting their research, these senior investigators can serve a dual function by becoming mentors to the more junior investigators. However, mentoring is not

a task for all and the selected mentors have to: ① be interested in the art of mentorship, ② secure independent funding for their research, ③ be known in the field of interest so their students can get to know other active and productive, and ④ be capable of networking and introduce their mentees and students to others. It should be clear that all investigators, junior and senior, must have a commitment to inquiry and a desire to collaborate with other investigators. The need for collaboration skills is directly related to the nature of the complex and multidimensional problems that need to be solved in rehabilitation. It is reasonable to suggest that a team approach, similar to our standard practice in the rehabilitation hospital or clinic, is also needed in PRM research.

A second important element of capacity building is the availability of physical resources for the conduct of research. Both, space and equipment are needed although high-quality research is more dependent on the inventiveness of the investigator than on the availability of expensive and sophisticated devices. Institutions have to develop an infrastructure that responds to the needs of investigators. Seed money and space must be available for starting new laboratories and lines of research that require new equipment and technical personnel. Many institutions are building space that can be shared by different groups and new laboratories can take advantage of these core facilities. A more important obstacle to the enhancement of research capacity is the lack of recognition of research and scientific discovery as an institutional, organizational, and professional core value in many institutions and professional groups. All too often, scientific discovery is not an explicit priority in the vision and mission statements of clinical and professional organizations and institutional strategic plans do not promote collaborative or interdisciplinary research and are not expressly supportive of the investments needed. In other words, success in scientific research must be recognized, valued, and rewarded in academic and health care systems if we want to encourage young professionals to dedicate their lives to it.

A third requirement for the enhancement of research capacity is the allocation of funding by governments or the private sector to support the research efforts. Financial support is needed at different stages of a career and current funding mechanisms in different countries do not necessarily provide continuity. In other words, many investigators working on important problems may find their funding stream interrupted and some may abandon research altogether. To encourage the development and retention of investigators, funding must be increased for pre-doctoral students, post-doctoral fellows, junior faculty, and established investigators transitioning into new investigative areas. The first three mechanisms would provide support for talented individuals who may be establishing promising research programs but do not have long-term funding commitments from public or private sources. In my opinion, traditional funding mechanisms and strategies are not sufficient to accomplish this goal and do not provide adequate opportunities for those at the beginning of a career or on a transition phase of their research. The latter is an important mechanism for rehabilitation because it has been proposed that we need senior and established investigators in other fields to transition and focus their intellectual efforts on problems relevant in PRM and rehabilitation. The start of a new line of scientific inquiry is not an easy task for an established investigator unless new resources are assigned to support the researcher. A final note of caution is important. The capacity to obtain funding, in and of itself, should not be considered the best way to measure the quality of a scientific program. Although financial support is always needed, funding should recognize outcome and the measure of scientific success should be the scientific output – the elucidation of new knowledge and its dissemination through publication-and not the amount of funding obtained by any scientist.[7]

An important strategy to enhance research capacity and to maximize the possibility of finding solutions to complex problems, such as those commonly seen in rehabilitation, is the establishment of collaborations and partnerships. Partnerships with scientists in PRM and other disciplines, academic departments, institutions, communities, and with patient advocacy groups are vital to enhancing the capacity for conducting high-quality, meaningful research. The interaction among scientists, physicians, and persons with disabilities who may see problems from different perspectives, has the potential to result in creative approaches to research questions and innovative solutions. Finally, from a practical point of view, collaborations with colleagues in other fields may give PRM researchers access to existing resources and core laboratories in their own institution and diminish the acute need to develop a completely new infrastructure for rehabilitation research.

Finally, it is important to regularly evaluate the outcomes of all the above-mentioned strategies. Efforts to enlarged research capacity must be complemented by the ability for assessing that capacity over time in order to gauge progress. Some of the traditional metrics used to assess research capacity include: ① number of investigators, graduate students, and post-doctoral students; ② number of funded grants; ③ amount of resources including research space and equipment; ④ number of peer-reviewed publications and presentations. However, we should not lose sight of the fact that the most important outcome is the

generation of new knowledge that contributes to the design and implementation of new preventive, therapeutic, and rehabilitative interventions. In the latter sense, the most important metric in the future will be the number of problems that have been resolved and the contribution of the field to the enhancement of the quality of life of people with disabilities.

Research Agenda

It is very important to have the research capacity needed to conduct high-quality research but the nature of the research should be driven by the scientific agenda and the identification of important problems and not by the availability of some space, equipment or techniques[8]. Just as important is the anticipated impact of the research results. Defining a scientific agenda for any field of study is not an easy process. Yet, it is a necessity if we want to move that field forward. In the case of PRM, the difficulty in defining an agenda relates to a number of factors. Some of the most commonly cited are: ① the broad nature of the field of study ranging from the basic biology of disability to the psychosocial determinants of participation; ② the wide variety of interests of scientists and researchers in PRM and rehabilitation; ③ the geographical variability of the medical rehabilitation problems and priorities making an international consensus more difficult to achieve; ④ the complexity of defining and measuring outcomes related to function, activity, and participation; ⑤ the general "free" nature of the scientific process where the pursuit of ideas cannot be mandated nor strictly controlled without putting at risk the capacity to innovate. Despite these differences we in PRM should agree on some basic criteria that can help us pull together an agenda. From our point of view, the scientific agenda must be defined based on the knowledge gaps in PRM and rehabilitation, the nature and identification of the clinical problems "ripe for resolution", and the needs of persons with disabilities as defined by them in collaboration with scientists and clinicians.

It is fair to suggest that research efforts in PRM should be defined by a well-balanced combination of basic, clinical, and psychosocial science. However, too often, basic science research is not perceived as close enough to rehabilitation. Basic science research in rehabilitation must be supported while integrating approaches that are common to other health professions and medical specialties. Further, if we want to have an impact on real life problems, clinical and translational research must occupy a special place in the research agenda. In other words, we need to make sure that our research enterprise is designed to translate basic science findings from the laboratory into clinical knowledge useful and applicable in health delivery systems for the benefit of people with disabilities.

Research Themes

Many scientific fields have seen dramatic advances in the last 50 years. While maintaining our focus on the ultimate goal of enhancing the health and quality of life of people with disabilities around the world, the field of PRM should take advantage of the dramatic increase in general scientific knowledge, advances in research methodology, and technological innovations to enhance rehabilitative efforts. I would like to briefly consider some areas of biomedical research compatible with this model because of the potential applicability and impact on PRM. Many others can be identified but the following should serve as examples in support of the proposed agenda.

A case in point is the revolution in genetics that started in the 1950′s with the discovery of the structure of DNA and continued with the description of the human genome into the 21st century. The science of genetics may help us understand, among other things, why patients with the same basic disease or condition respond differently to similar or equivalent rehabilitative interventions [9]. Could the genotype be an important predictor of an individual′s response to rehabilitation? Can simple genetic tests be developed to use this predictive value and individualized treatment approaches? Although we all know that the complexity of functional loss, limited activity, and restricted participation cannot be reduced to the biology of genes and gene products, it is not reasonable to exclude them either. Further, many chronic diseases have a genetic component and the response to acute interventions such as pharmacotherapy may be determined by the genetic makeup of the individual as recent advances in the field of pharmacogenomics have shown. Understanding this potential role of the genotype, rather than ignoring it, may help us move the field of PRM forward.

Many diseases and conditions that lead to significant and many times permanent functional loss (i.e., osteoarthritis, stroke, brain injury, organ failure) are associated with tissue damage. Thus, the goals of protecting tissue from damage and repairing or replacing damaged tissue early in the disease or injury process seem extremely relevant to PRM and rehabilitation. Would it be possible to use stem cells and other regenerative techniques to replace the tissue that has been damaged and lost [10]? Can stem cells and exercise therapy (and other rehabilitative interventions) result in a synergistic effect[11]? What about the potential contribution of the field of tissue engineering? By definition, tissue engineering/regenerative medicine is an emerging multidisciplinary field involving biology, medicine, and engineering that is likely to revolutionize the ways we

improve the health and quality of life for millions of people worldwide by restoring, maintaining, or enhancing tissue and organ function. Clearly, rehabilitation involves more than tissue function but the relationship between tissue structure and function is a well accepted paradigm in medicine and recent advances in this field may help us limit the magnitude of the tissue loss and its impact on the degree of disability. Undoubtedly, this is a goal worth pursuing.

Multiple therapies in PRM and rehabilitation address the goal of enhancing the capacity of partially impaired or even healthy tissues surrounding the injured area. Traditionally, this training has been conducted with standard exercise routines under the supervision of therapists or trainers. Recent technological and engineering advances have allowed the development of various types of robots to enhance our ability to train these tissues to take over the function of the damaged tissue [12]. Robots may enhance the efficiency of the clinic by allowing several patients to be trained simultaneously under the supervision of one therapist. Further, robot-aided training allows the standardization of the intervention and the quantification of the performance of the patient during and after training. During the last few years a number of research groups have developed robots to also enhance the performance of activities of daily living in persons with disabilities and some tasks that are essential in occupational environments. We need to understand more the technology needed to accomplish rehabilitation goals, the potential benefit of these devices, and their role in the rehabilitation of different types of conditions.

Materials and devices have always been central to the fulfilment of rehabilitation goals in various populations. For example, patients with limb loss, spinal cord injury, and brain injury depend on the use of assistive and technical devices for a wide variety of functions and tasks. A group of emerging technologies in which the structure of matter is controlled at the nanometer scale, the scale of small atoms, is being used to produce novel materials and devices that have useful and unique properties [13]. Nano-technology has the potential to increase our capabilities to diagnose clinical problems, intervene early in the disease process, build better assistive devices, and replace function with new technologies. In the future, replacing function with devices built to order specified by a functional requirement will help us achieve functional goals quicker and more effectively.

Clearly, this is not an exhaustive list of recent scientific and technological advances and many other important and related discoveries can be identified. A detailed discussion of these advances is beyond the scope of this article. Although I have limited my comments to research themes closely related to biomedical and engineering research, in PRM, we need to address other important issues that may be more closely related to rehabilitation than to other fields. The development of new measurement techniques and instruments specific to functional outcomes, the impact of new technologies on return to work statistics, the influence of psychosocial problems as determinants of the effect of rehabilitative interventions are some additional important areas for future research efforts.

Relevance of Clinical and Translational Research

Significant interest has been generated in the United States and other countries on the topic of clinical and translational research [14]. This type of research is considered essential to the mission of bringing scientific discoveries quickly into the clinical realm and to turn them into interventions that will have a direct impact on public health and health care delivery systems. But, what is clinical research? The United States National Institutes of Health define clinical research as research that either directly involves individual people or uses materials of human origin, such as behavior or tissue samples, that can be linked to a particular living person. In general, clinical research can be divided into three different types:

① Patient-oriented research: this type of clinical research involves human subjects or materials from human subjects and can include studies of mechanisms of human disease, studies of therapeutic interventions, clinical trials, and development of new technology; ②Epidemiological and behavioral studies: these types of studies examine the factors that affect health and health-related decisions; ③Outcomes and health services research: these studies seek to identify the most effective and most efficient interventions, treatments, and services.

It should be clear to the reader that many problems in rehabilitation and most research studies in PRM can be classified into one of the three groups mentioned above. Therefore, it is reasonable to suggest that this development and interest in clinical research could be of significant benefit to our field and must be considered in our discussions about the research agenda for the field. Further, the discussion about this research paradigm incorporates the concept of translational research with an emphasis in transforming scientific discoveries in the laboratory, clinical or population studies into applications that improve health outcomes and public health. Translation can occur from the bench to the clinic when laboratory observations in non-human models of research result in hypotheses that are tested in a human clinical trial. Another example is when successful clinical trials support interventions that can be translated into a standard practice (policies, guidelines) in the health care system. Then, it is at the level of the system that effectiveness and outcomes research must be

conducted to show improvement in public health. Further, it should be noted that translation can and does occur in both directions, for example, when clinical findings in a particular patient leads to the search for the basic biology of the condition. One example may be the search for the virus responsible for HIV after the clinical syndrome was described and recognized.

The field of PRM needs to discuss this research model and apply it wherever useful. It is encouraging to see that there are clear signs that this is already happening. The web-based system www.clinicaltrials.org is a registry of clinical trials around the world. More than 70,000 active clinical trials had been registered in 172 countries by the month of August 2009 and more than 1000 were related to rehabilitation; the majority in the United States and Europe.

A Proposal for an International Consortium

Given the above discussion about the particular nature of problems and knowledge gaps in PRM, the importance of partnerships and collaborations in building research capacity, the need to reach a consensus regarding a scientific agenda, and the strength of multicenter collaborative studies it is reasonable to suggest that the PRM community should develop a global consortium of research centers to conduct research projects that will benefit people with disabilities around the planet. The purpose of this consortium will be to facilitate the exchange of ideas, support the planning of studies to address key research questions and clinical problems, contribute to the design of studies that require a large sample size, and facilitate the conduct of research tackling multicultural issues.

It is also reasonable to suggest that an organization such as the International Society of Physical and Rehabilitation Medicine (ISPRM) could take the lead in building a virtual community of research centers in different institutions and countries to accomplish this goal. Although many details about the organization of such a community of centers and researchers have to be decided, at a minimum, the members of the consortium could use modern technology to disseminate information about ongoing projects in their home institutions. An international registry of research projects can be created. Also, proposals for multicenter studies could be discussed by members and posted for the consideration of centers that may want to join the consortium. Finally, groups of researchers from different countries may help with the design of important studies for the field of PRM and offer their expertise in the analysis and interpretation of data. Other national and international groups have assembled networks of laboratories and research groups in the past with excellent results. The challenges of such an undertaking are obvious but the rewards can be quite significant and should be evident to those who know the field.

Concluding Remarks

It is clear that the field of rehabilitation research in general and PRM in particular have made significant progress in the last two decades. We feel more confident today in our knowledge base than a few decades ago. Nevertheless, the needs are many and it is imperative that we do more. Institutions and professional organizations in PRM should invest more in building research capacity. Further, we should come together and develop a scientific agenda with the consensus of all interested in the future of PRM. A special emphasis should be given to clinical and translational research. One way of achieving our goals is the development of a consortium, a virtual community or network, of research centers around the world. Our contribution to a better future society without barriers depends on it.

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