Background on the 3rd International Congress "Restoration of (wheeled) mobility in SCI rehabilitation": State of the art III

INTRODUCTION

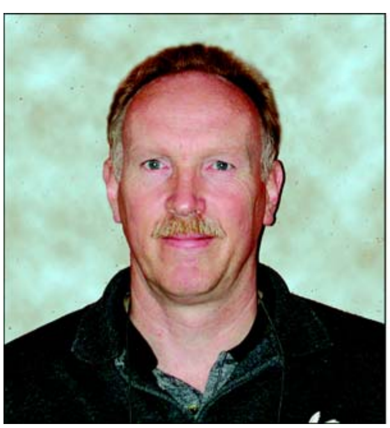
"Restoration of (wheeled) mobility in SCI rehabilitation" was the theme of a recent International Congress in Amsterdam, April 2004. Restoration of mobility in spinal cord injury (SCI) in its ultimate form would be to remove the cause of the mobility limitation, i.e., curing the SCI. Despite a large and basic research effort on neural regeneration on spinal cord repair and on damage preventive—early intervention—strategies [1–2], no cure is available today for spinal cord damage. In contrast to the strong financial research stimuli and the growing expectations on the success of neural repair as a cure for SCI, today's reality is that SCI is not curable.

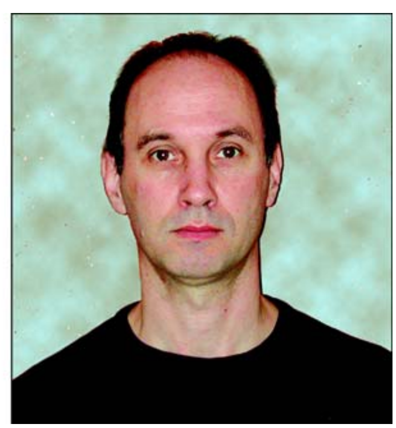
SCI has long-term and far-fetching consequences for daily functioning and freedom of mobility. As such, an inevitable need exists for applied and basic research into SCI rehabilitation; into its goals, strategies, and practices; and where possible, into new and innovative avenues of care improvement. This need was the focus of the 3rd International Congress "Restoration of (wheeled) mobility in SCI rehabilitation: state of the art III." The following is a retrospective, both on the evolution of the research work of the research group at the Faculty of Human Movement Sciences in Amsterdam that formed the basis for the program themes as well as a personal opinion on the research issues that are currently evolving from the rehabilitation field within the framework of restoration of mobility.

MOBILITY

Although mobility is an essential element in daily living, its importance is usually only recognized when it is for some reason (temporarily) limited. Mobility is a multilayered concept. One can speak of joint mobility, but also of mobility as a form of daily activity, and even within the context of participation, we use the term mobility. All three mentioned connotations of mobility substantiate main objectives of an integral rehabilitation process. As such, mobility can be positioned at each of the three domains of functioning within the International Classification of Functioning, Disability and Health (ICF) model [3]. This model is in many ways the starting point of research activities that are briefly reviewed in this paper (**Figure 1**).

Within the context of a chronic impairment, rehabilitation focuses on restoration of locomotion, ambulation, or mobility in its widest sense. Continuing to be a mobile individual and having an optimal social and physical range of action are key objectives in SCI rehabilitation. In today's rehabilitation field,





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this goes beyond the mere restoration, compensation, and (technology-based) adaptation of sensor-motor function, activities of daily living (ADLs) functionality, and independence. Having a physically active lifestyle during and after rehabilitation is becoming an issue on the rehabilitation research agenda [4–7].

THE INTERNATIONAL CONGRESS

The central theme of the 3rd International Congress was the restoration of mobility in SCI. The meeting was focused on combining knowledge of exercise regimes, practice modes, learning and training protocols, rehabilitation strategies, and front-edge assistive technology. Understanding of the underlying mechanisms and processes of adaptation and/or compensation of function and functioning (with or without the use of optimal assistive technology) is the core of rehabilitation research. The rehabilitation paradigm can be summarized as “to restore function and functionality and to stimulate optimal activity and participation,” a multicausal and multilayered concept. As a theoretical framework, the ICF model was taken as a starting point for the program of the 3rd International Congress: mobility and function, mobility and activity, and mobility and participation, respectively. Issues that were addressed were as diverse as hand-arm functionality, including orthotics and functional electrical stimulation (FES); treadmill walking; FES cycling; hand-cycling; wheelchair propulsion; seating; physical activity and life style; mobility-related secondary health problems; functional independence; quality of life; well-being; cultural and immigrant background; and participation. A sample of the excellent presentations and research work performed can be found in this special issue.

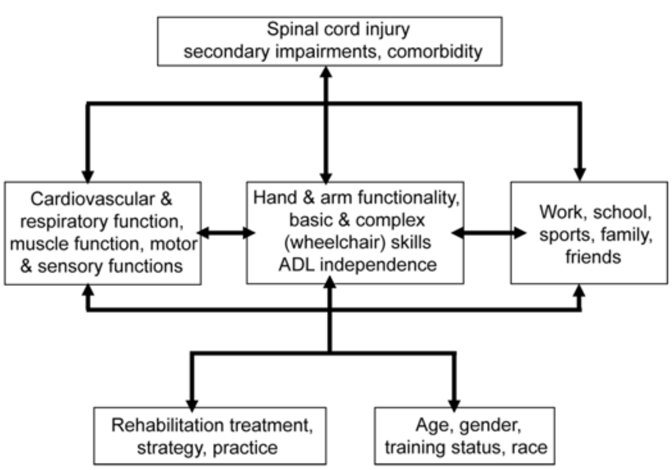

Figure 1.
International Classification of Functioning, Disability and Health (ICF) model—health in spinal cord injury.

The history of the 3rd International Congress dates to the early 1990s and explains the adjective “(wheeled)” in the title of the Congress. In 1991, a first international scientific workshop on wheeled mobility was held at the Vrije Universiteit, Amsterdam. This first workshop was fully dedicated to manual wheelchair propulsion [8]. The second workshop was held again at the Vrije Universiteit in Amsterdam in 1998 and focused on (wheeled) mobility issues and questions on SCI rehabilitation [9]. The 3rd International Congress can be viewed as a further widening of the scope from wheeled mobility to a broader concept of mobility.

FROM WHEELCHAIR RESEARCH TO A MULTIDISCIPLINARY PROGRAM

The scope of the 3rd International Congress has undergone a parallel development as the work on wheelchair propulsion since 1983 at the Faculty of Human Movement Sciences in Amsterdam, the host for all three meetings. This research line started with a combined physiological and biomechanical approach into the optimization of wheelchair propulsion ability [10–11]. Different performance-influencing aspects, especially the ergonomics of the wheelchair-user interface, individual physical work capacity, and various aspects of propulsion technique, were studied, as well as aspects of vehicle mechanics. Recently, biophysical aspects of the learning process of hand-rim wheelchair propulsion were incorporated [12], and hand-cycling as a more efficient alternative mode of ambulation became part of the research topics [13–14]. With the increasing understanding of wheelchair mobility came a growing interest in the mechanical consequences of long-term wheelchair use: the quest for the mechanisms and consequences of musculoskeletal overuse in wheelchair use and ADL [13–17], especially in those with SCI. Apart from longitudinal research, in which epidemiological and experimental techniques are combined, this problem requires the use of detailed techniques for kinematics and kinetic [11,18–19], as well as upper-limb modeling tools [17,20–21].

ASSISTIVE TECHNOLOGY

The interaction between assistive technology and the (disabled) human system is complex by definition and requires detailed research from a combined ergonomics and rehabilitation perspective. As an example, the long-term use of assistive technology and its consequences on the musculoskeletal system has become an important issue in manual wheelchair research, where the continued imbalance between the task stresses, physical strain, and overall mechanical and physiological work capacity leads to overuse of and injuries in the upper limb [22]. Also if assistive technology for mobility and the biological system do not function optimally, a debilitative cycle may start that can lead to an inactive lifestyle and consequently to a possible increased risk for secondary impairments, such as cardiovascular disease [23–24]. This stresses the important preventive role of an ergonomics approach within the field of rehabilitation and assistive technology.

Within the broader context of reactivation and restoration of mobility in SCI, biotechnical-oriented SCI research recently evolved not only in the field of wheeled mobility but also with walking, i.e., body-weight-supported treadmill walking [25–26] and the use of gait-assisting robotics. Also, robotics in ADL and upper-limb support [27–28] and the upper-limb neuroprostheses for those with tetraplegia [29–31] are examples of specific assistive technology that support restoration of function and functionality in SCI. Electrically stimulated (ES) cycling has been in the field for two decades. The therapeutic use of stationary recumbent ES bicycles in SCI has become common in some countries and has stimulated the development of technology for ES recumbent cycling in real life [32–35], allowing a more active lifestyle even in high-lesion SCI. These devices will require the input of an ergonomics-oriented research to reach an optimal long-term functioning of the "assistive technology-user" combination.

(IN)ACTIVITY

After the importance of a physically active lifestyle was recognized for the general population through research [35–38] and by influential (political) bodies such as the American College of Sports Medicine,[*] Center for Disease Control,[†] and World Health Organization,[‡] evidence was found that (restoration of) an active lifestyle is probably even more important for those with a chronic disease or those involved in (clinical) rehabilitation [4–7,39].

The focus on the health-related mobility problem of a wheelchair-confined life in individuals with SCI was recognized by Hjeltnes and Vokac [23] and later initiated in our research group by Janssen et al. and Dallmeijer et al. [24,40–41]. More and more, the risks of a sedentary lifestyle have become apparent in international literature as being one of the keystones to many chronic diseases, such as type-2 diabetes, syndrome X, or cardiovascular disease [4–7,39]. The prominent role of physical activity and lifestyle in the development or, better, prevention of long-term health problems has become a specific issue that is clearly translated into the Congress program theme and will have to be on the rehabilitation research agenda.

Apart from the common use of questionnaires for (in)activity and lifestyle research, the use of small computer-based activity sensors has also entered activity monitoring in the field of rehabilitation [42–44]. Only few physical activity questionnaires are available for specific use in rehabilitation populations [39], while the more complex sensor techniques require elaborate validation and reliability research for different subpopulations. They do allow, however, observing the quantity as well as quality of

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[*] www.acsm.org
[†] www.cdc.gov/nccdphp/dnpa/surveill.htm
[‡] www.who.int/hpr/physactiv/health.benefits.shtml

ambulation in real life over a longer period of time, thus opening ways to stimulate and advise on activity and lifestyle, as well as quality of movement [42–44].

FROM OUTPATIENT TO INPATIENT RESEARCH

For the Faculty of Human Movement Sciences, at a Dutch university, the transfer from outpatient to inpatient rehabilitation research was a major step that only became possible with the close collaboration with local rehabilitation centers, especially the Rehabilitation Center Amsterdam.[*] SCI research within the Faculty of Human Movement Sciences and Institute for Fundamental and Clinical Human Movement Sciences over the years shifted away somewhat from the “wheelchair core business” only, toward other forms of locomotion (i.e., hand-cycling and electrical-stimulation-induced leg-cycling) and more fundamental issues of cardiovascular adaptation [45–47], muscle physiology [48], and biomechanical upper-limb modeling [16–17,21]. Apart from changes in the biology due to the initial paralysis, long-term effects of chronic inactivity in SCI are studied, as well as the restoring effects of lower-body exercise. The latter is often in the form of electrically stimulated leg-cycling [49] and addresses both cardiovascular adaptation and muscle physiological aspects. The importance of more systematic research into underlying biological processes and mechanisms of adaptation and compensation of function and functioning in SCI is evidently expressed in this special issue, but also in today’s literature.

RESTORATION OF MOBILITY IN SCI REHABILITATION: A RESEARCH PROGRAM

The 2004 Congress also has its roots in the multidisciplinary research program “Functional strain, work capacity and restoration of mobility in the rehabilitation of persons with a spinal cord injury,”[†] which was initiated in 1998 and naturally evolved from the earlier wheelchair and SCI research. This program, in short, “Restoration of mobility in SCI rehabilitation,” is a multicenter collaboration among five research groups, SCI units of eight rehabilitation centers in the Netherlands, and the Dutch-Flemish Society of Paraplegia (NVDG).[‡]

The multicenter program is presently formed by 12 complementary research projects, which cover various aspects of restoration of mobility in its broadest context. The benefits of such a long-term multidisciplinary collaboration and the availability of larger numbers of subjects are evident. The development of this multidisciplinary program was only possible given the special infrastructure of Dutch rehabilitation healthcare and densely populated Dutch society, with the financial support of Rehabilitation Program of ZONmw,[§] a national organization that promotes quality and innovation in the field of health research and healthcare.

This in turn facilitates the structured implementation of newly developed knowledge in the healthcare system and guarantees emerging healthcare issues a place on the research agenda. The backbone of the research program is formed by a prospective-cohort study. Over 200 patients with SCI during and 1 year after initial rehabilitation performed a series of function and functional tests. The project measures each patient four times with a standardized array of questionnaires and tests—among which arm-hand function tests in those with tetraplegia, a wheelchair skills test and maximum wheelchair exercise test on a motor driven treadmill (**Figure 2**), and a walking test in those with an incomplete lesion—and questionnaires covering many different aspects at each level of the ICF model. Understanding the complexity of restoration of mobility in SCI requires large subject numbers, combined experimental and epidemiological studies over time, and complex multilevel statistical techniques

[*] www.rcamsterdam.nl

[†] www.fbw.vu.nl/onderzoek/A4zon/ZONenglish

[‡] www.nvdg.org

[§] ZONmw, Netherlands Organization for Health Research and Development, www.zonmw.nl

Figure 2.
A maximal wheelchair exercise test on a motor-driven treadmill.

[13,30,50–53]. A strong need exists for such large group multidisciplinary prospective studies in rehabilitation for theory development and the evidence-base of treatment [54], from which future intervention studies as well as experimental studies must be derived. Some of the initial program results are presented in this special issue.

CONCLUSION

Clearly, rehabilitation research has a need for multidisciplinary collaboration and exchange to tackle the (methodological) research questions and practical problems of today and to be prepared for the issues of tomorrow. An in-depth understanding of the origin and consequences of impaired function and functionality, the opportunities for treatment, and the prevention of secondary problems often requires not only multicenter and longitudinal collaboration but also the multidisciplinary approach of experimental and intervention studies. Research into assistive technology for mobility must address the optimization of the interaction of the biological system to prevent long-term health problems as a consequence of overuse. This and other issues require both specific and generic measurement tools and technology. International Congress activities will contribute to these goals and processes.

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