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Fitness and Conditioning during Spinal Cord Injury (SCI) Rehabilitation

"Importance of exercise, active lifestyle and sports in recovery of persons with spinal cord injuries: results from the Dutch multicenter prospective SCI cohort study"

Araştırma Makalesi

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ABSTRACT

Little is known of the outcome and effectiveness of clinical rehabilitation on physical activity, mobility, fitness, functioning in society or quality of life. A multi-disciplinary research collaboration and multicenter prospective cohort study (www.scionn.nl) was conducted and studied the course of restoration of mobility of persons with spinal cord injury (SCI). The International Classification of Functioning, Disability and Health (ICF) served as a conceptual framework. A total of 225 SCI from eight Dutch specialized units participated. A variety of physical tests and questionnaires were administered at standardized moments during (3x) rehabilitation, and one and five years after rehabilitation. Results over time were analyzed with multi-level regression analysis ($p<0.05$). Multi-level analyses showed significant improvements in fitness and functioning in a wide range of outcome measures. Apart from muscle strength and lung function, wheelchair exercise capacity as measured in (sub) maximal hand rim wheelchair performance showed significant improvements in early rehabilitation, yet stabilized between one and five yrs post discharge. Those with paraplegia, younger and male persons showed higher values on the functional outcome measures. Different subgroup trajectories may be discerned among the population at study. Similar overall group trends were seen in wheelchair ADL skills. Musculoskeletal pain in the upper extremities is already seen at the start of active rehabilitation (shoulder pain in paraplegia 28%, tetraplegia 55%). Additional experimental studies showed higher internal mechanical strain at the glenohumeral joint in those with tetraplegia during standardized wheelchair ADL. In contrast to expectations the trend in lipid profiles was rather

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positive during rehabilitation (but not BMI). Profiles showed a tendency to deteriorate after rehabilitation. Longitudinal multi-center research during and after regular SCI rehabilitation proves feasible and fruitful; results show positive trends at the group level regarding rehabilitation treatment and development towards a more active lifestyle.

Key Words

Fitness, Conditioning, Spinal cord, Rehabilitation

INTRODUCTION

The basis for a physically active lifestyle and participation in adapted physical activity for many individuals with a disability will be laid during the initial phase of clinical rehabilitation. Little is known of the outcome and effectiveness of clinical rehabilitation on physical activity, fitness and restoration of mobility. A spinal cord injury is a common and typical diagnosis in clinical rehabilitation, often involving relatively young and active individuals. 'Restoration of mobility in spinal cord injury (SCI) rehabilitation' is a multi-disciplinary research collaboration and a multi-center prospective cohort study[a]. The purpose of this research program is to describe, analyze and understand the course of restoration of mobility and functioning during and after inpatient rehabilitation of persons with a spinal cord injury, both at the organ level as well as at the level of the individual, thus helping the theoretical underpinning and improvement of the SCI rehabilitation treatment and the understanding of the outcome on daily activity and fitness during and after rehabilitation in the context of different patient and process related determinants (Bloemen-Vrencken, 2006; Van Koppenhagen, 2013).

Eight Dutch rehabilitation centers with a specialized spinal cord injury unit, five academic rehabilitation research centers and the Dutch-Flemish Society of Paraplegia conducted this longitudinal study. This prospective-cohort study is part of a network of 16 simultaneous experimental projects, dedicated to different complementary aspects of the complex issue of mobility restoration in SCI. Mobility in this context is defined as a broad concept, covering function and structure, as well as the domains of activities and participation from the International Classification of Functioning, Disability and Health (ICF; WHO, 2001).

METHODS

Eventually 225 individuals with SCI participated in this prospective-cohort study in which mechanisms of restoration of mobility and daily functioning were investigated with a test battery, largely following the domains of the ICF model (Figure 1.) (WHO, 2001). Beyond the conceptual ICF framework the study is based on the stress-strain-capacity model of Van Dijk (Van Dijk, et al, 1990). Figure 2. stresses the importance of monitoring and stimulating physical activity, sports, training and skill learning during and after rehabilitation for functioning, participation and quality of life.

A wide variety of physical tests and questionnaires were administered at standardized moments during (3x; at the start of active rehabilitation, 3 months later, and at the end of clinical rehabilitation; t1-t3), a year (t4) and 5 years after rehabilitation (t5). Results over time and the effects of different lesion and person characteristics were analyzed with multi-level regression analysis ($p<0.05$). This prospective cohort study started just at the start of the new millennium and has generated over the different stages of project activities a vast range of scientific publications (Bloemen-Vrencken, 2006; Van Koppenhagen, 2013; de Groot, et al., 2007).

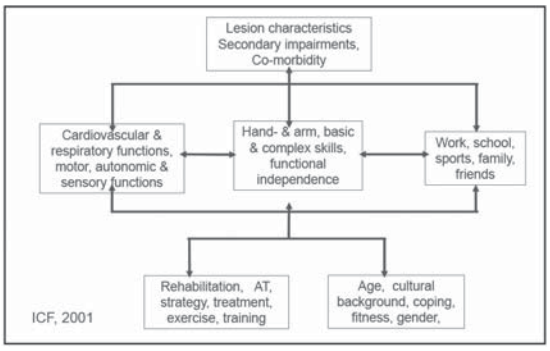

Figure 1. Domains of the ICF model, applied to SCI Rehabilitation

RESULTS

The research group at t1 mainly consisted of men (74%), and individuals with paraplegia (59%) and a complete lesion (68%). SCI was mainly caused by a trauma (75%), principally due to a traffic accident (42%)[b.] 139 Persons had a fracture to one or more vertebrae at the start of rehabilitation. Apart from the motor paralysis below the level of the lesion, persons with a spinal cord injury experience a fast adaptation to a much lower level of activity and disuse in the cardiovascular system, which is expressed in smaller, heart and blood vessels, which in turn may affect cardiovascular health in the long run (De Groot, 2005).

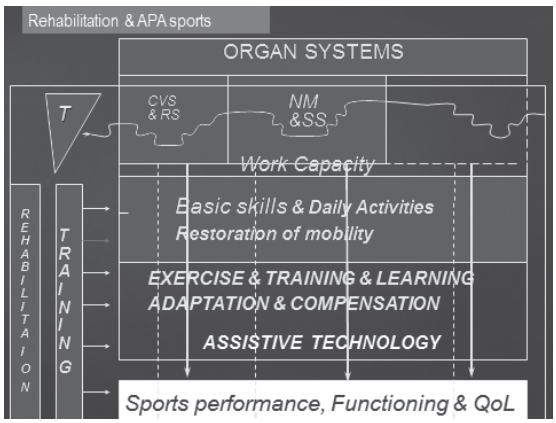

Figure 2. Rehabilitation and APA & Sports.

The length of clinical rehabilitation in the Netherlands varied between 2 months and more than a year, depending on lesion characteristics and co-morbidity, but seems quite long in the light of functional independence.

Multi-level analyses of the time-related changes showed significant improvements in functioning in a wide range of outcome measures: in the Functional Independence Measure outcomes, but also in more function and functionality-oriented measures. Apart from muscle strength and lung function, wheelchair exercise capacity as measured in (sub) maximal hand rim wheelchair performance (peak power output, oxygen uptake) showed significant improvements during rehabilitation the initial phase of rehabilitation. Improvements in the beginning of rehabilitation (t1-t2) were higher compared to the latter part of clinical rehabilitation (t2-t3). Work capacity stabilized between one and 5 yrs post discharge (Haisma, 2008; Van Koppenhagen, 2013). Those with a paraplegia showed higher values on the functional outcome measures. More beneficial levels of performance were evidently seen for younger and male individuals.

Similar results were seen on the wheelchair circuit in a series of eight standardized wheelchair ADL tests. Again wheelchair skills stabilized between 1 and 5 yrs post discharge (Kilkens, 2005). The fitness as well as wheelchair skills scores at t4 were a significant cross-sectional predictor of participation as reflected in the SIP68-SOC score (Dallmeijer, 1998; Kilkens, 2005). More recent work showed a positive cross-sectional association between fitness and return-to-work (van Velzen, et al., 2009), while Van Koppenhagen et al showed an association with well-being (Van Koppenhagen, 2013).

With wheelchair skills, gross mechanical efficiency of hand rim wheelchair propulsion on a motor-driven treadmill showed a slight but significant improvement during active rehabilitation (de Groot, et al., 2007). The outcome measures for wheelchair skills showed a strong association with the different fitness parameters, while the fitness parameters showed strong simultaneous trends as well. Musculoskeletal pain in the upper extremities is already present at the start of active rehabilitation in a majority of the group (shoulder pain in paraplegia 28%, tetraplegia 55%). Overall musculoskeletal pain remained constant during t1 and t2, but decreased somewhat thereafter. A higher pain score was seen in those with tetraplegia, and those with a lower muscle strength or FIM score. Additional experimental studies showed higher internal mechanical strain at the glenohumeral joint in those with tetraplegia during standardized wheelchair ADL. During the vertical lift, those with tetraplegia experience an extra mechanical shoulder joint compression force of 550N as compared to those with tetraplegia

(Van Drongelen, 2005). In more recent modeling work of Arnet et al, handcycling proved far less straining to the glenohumeral shoulder joint as opposed to handrim propulsion (Arnet, 2012), while Valent et al already had shown that handcycling is feasible in early rehabilitation, since it is more efficient (Valent, 2009).

In contrast to expectations based on data in persons with a long term spinal cord injury, the trend in the lipid profile was rather positive during rehabilitation, probably due to the active lifestyle in that period, but showed a tendency to deteriorate after rehabilitation (de Groot, et al., 2008).

DISCUSSION & CONCLUSION

The personal and lesion characteristics of the subjects of the multi-center study were comparable to data of other studies, although fewer older subjects and subjects with an incomplete lesion were included due to the inclusion criteria 'age' and 'wheelchair-dependent'. It can be concluded that indicators of fitness, functioning and wheeling ability show significant improvements over the clinical rehabilitation both in persons with a paraplegia and a tetraplegia. In general, those with paraplegia and a lower age showed a significantly better functional outcome. Overall, absolute performance level is lower in those with tetraplegia, as can be expected. Whether progress is optimal for the different subpopulations is hard to say at this stage. Musculoskeletal pain is present in early rehabilitation among a large group, especially those with tetraplegia. Both wheelchair use and daily activities may be a risk factor here. Balanced endurance based exercise of upper body musculature – such as handcycling - may be preventive, as well as the limited use of hand rim wheelchairs in the early rehabilitation stage. In early rehabilitation handrim wheelchair skill and capacity may be built using low-intensity training. Lipid profile does not suggest high risk during rehabilitation in this population yet, but given the expected lifestyle after rehabilitation and specific physiology in SCI, caution should be taken in continued cardiovascular monitoring. The same holds for indications for musculoskeletal overuse.

Furthermore, it was found that the length of stay in rehabilitation centers in The Netherlands was longer compared to Denmark, but much longer than in e.g. Australia and the USA. Functional restoration overall showed a higher improvement during t1-t2 compared to t2-t3 or t4-t5.

Longitudinal multi-center research during and after SCI rehabilitation proves feasible and fruitful regarding the understanding of rehabilitation treatment. The study has led to the definition of a set of outcome measures for a standardized patient monitoring system during SCI rehabilitation with a concomitant norm database, thus contributing to the evidence-base of the individual SCI rehabilitation strategy. Whether fitness and daily physical activity and sports activity during rehabilitation is optimal, is unclear. It is expected that the increasing trend in fitness and functionality will deteriorate after conclusion of clinical rehabilitation.

Author Note:

[a]The research project 'Restoration of mobility in spinal cord injury (SCI) rehabilitation' is a multicenter prospective cohort study and part of a multidisciplinary national research program and network that started in 1999 (www.scionn.nl). (Funded by ZONmw, project nr 14350003/0010;

[b]Further reading material on set-up, PhD studies and results of these and other outcomes can be found on www.scionn.nl.

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