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ORIGINAL REPORT

CORRELATION OF SHOULDER RANGE OF MOTION LIMITATIONS AT DISCHARGE WITH LIMITATIONS IN ACTIVITIES AND PARTICIPATION ONE YEAR LATER IN PERSONS WITH SPINAL CORD INJURY

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Objective: **To study the correlation between limited shoulder range of motion in persons with spinal cord injury at discharge and the performance of activities, wheeling performance, transfers and participation one year later.**
Design: **Multicentre prospective cohort study.**
Subjects: **A total of 146 newly injured subjects with spinal cord injury.**
Methods: **Shoulder range of motion was measured at discharge. One year later, Functional Independence Measure (FIM), transfer ability, wheelchair circuit and Physical Activity Scale for Individuals with Physical Disabilities (PASIPD) were assessed. Corrections were made for possible confounding factors (age, gender, level and completeness of injury, time since injury and shoulder pain).**
Results: **All subjects with limited shoulder range of motion at discharge had a lower FIM motor score and were less likely (total group 5 times, and subjects with tetraplegia 10 times less likely) to be able to perform an independent transfer one year later. Subjects with limited shoulder range of motion in the total group needed more time to complete the wheelchair circuit. No significant associations with the PASIPD were found in either group.**
Conclusion: **Persons with spinal cord injury and limited shoulder range of motion at discharge are more limited in their activities one year later than those without limited shoulder range of motion.**

Key words: spinal cord injuries; shoulder; range of motion; activities; participation.

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INTRODUCTION

Upper extremity function in persons with spinal cord injury (SCI) is important for activities of daily living (ADL), such as dressing, washing, and combing one's hair (1–2). For wheelchair-dependent persons an optimal shoulder range of motion (ROM) is especially important for transferring independently (3), performing activities such as toileting, getting in/out of bed, driving a car, and for participating in sports and other leisure activities.

Unfortunately, persons with SCI who use a wheelchair for their daily mobility are at risk of developing shoulder impairments, such as pain (4–6) or limited joint ROM (4–5, 7), both during initial rehabilitation and during the chronic phase. Shoulder ROM limitations in persons with SCI have been shown to be a problem in persons with SCI during initial clinical rehabilitation as well as after discharge (4). Persons with SCI are at risk of developing limited shoulder ROM because of immobilization and spasticity (7), which may lead to "frozen shoulder".

An important milestone during initial rehabilitation is discharge. Discharge is the transition to the day-to-day home situation, whereby all learned skills (abilities) are implemented in daily practice (performance). Based on the person's functioning during initial inpatient rehabilitation, a prediction of a person's functioning in the day-to-day home situation is made and, based on this evaluation, home care, assistive technology (AT) and interventions (for example physiotherapy) are organized. Detecting those persons at risk of performing poorly on activities and participation as early as possible is important to improve rehabilitation where possible, and subsequently organize care, AT and interventions and ensure optimal functioning of the person at home. Understanding the longitudinal correlation between shoulder ROM limitations in persons with SCI and performance in activities and participation is therefore important. When this correlation is shown to be present, it would be useful to study the influence of preventive interventions on shoulder ROM limitations and the influence of such interventions on performance on activities and participation. Although several studies of the correlation between shoulder pain and its consequences on activities limitations and participation restrictions have been published (3–5), only a few focus on the consequences of shoulder ROM limitations. To our knowledge, only one published study has investigated the consequences of limitations in shoulder ROM on activity limitations and participation restrictions in persons with SCI (4).

Ballinger et al. (4) showed that men with SCI (95% with paraplegia) and shoulder ROM problems had lower FIM scores,

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were less likely to self-propel a wheelchair, and were more likely to need maximal assistance with transfers. They also reported poorer health.

To improve our understanding of the relevance of limitations in shoulder ROM for rehabilitation treatment in persons with SCI, further insight is needed into the correlation between shoulder ROM limitations and activities and participation in a longitudinal perspective.

In addition to our previous work on the longitudinal development of limitations in shoulder ROM (7), this study investigates the predictive value of limitations in shoulder ROM in persons with SCI (paraplegia and tetraplegia, as well as in the subgroup of those with tetraplegia alone) at discharge from initial clinical rehabilitation on the performance of activities, wheelchair performance, making a transfer and participation 1 year after discharge. We hypothesize that, in persons with a SCI, a limited shoulder ROM at discharge predicts poorer performance on activities and participation 1 year later.

METHODS

Study design

Subjects. The present study was part of the Dutch prospective cohort study "Physical strain, work capacity and mechanisms of restoration of mobility in the rehabilitation of persons with SCI".

Subjects admitted to one of the 8 participating rehabilitation centres between May 2000 and September 2003 were included if they met the eligibility criteria: acute SCI, classified as A, B, C or D on the International Standards for Neurological Classification (8), between 18 and 65 years of age, using a wheelchair for daily mobility, sufficient comprehension of the Dutch language to understand the purpose of the study and not having a progressive or psychiatric condition that could interfere with constructive participation in the study (9).

Procedures. Measurements were conducted following a standardized protocol by trained research assistants at discharge of inpatient rehabilitation and 1 year after discharge. All subjects gave their written informed consent prior to the study, which was approved by the medical ethics committee of the Stichting Revalidatie Limburg and the Institute for Rehabilitation Research.

Shoulder ROM was measured in all subjects at discharge from initial rehabilitation. One year after discharge activities were assessed by total FIM motor score and wheelchair performance by measuring 2 items on the wheelchair circuit. Also participation was determined 1 year after discharge using the PASIPD. Possible confounders (age, gender, level of SCI, completeness of SCI, time since injury and presence of shoulder pain) were assessed at discharge to be able to correct for these factors.

Instruments/measurements

Personal and spinal cord injury characteristics. The age and gender of all subjects were recorded. Level and completeness of SCI were recorded according to the International Standards for Neurological Classification of SCI (10). Tetraplegia was defined as a neurological level of SCI above the T1 segment. A SCI was defined as motor complete when subjects met the criteria of the International Standards for Neurological Classification of SCI A or B.

Time since injury. For all subjects, time since injury (TSI) was determined as the time between the occurrence of SCI and the measurement time (noted in months).

Shoulder range of motion. Following a standardized protocol, passive ROM of both shoulders was measured in the sitting position for flexion, external rotation and abduction, using goniometry. Normal ROM was defined as: 180º for shoulder flexion, 60º for external rotation and 90º for glenohumeral abduction (10). A decrease in ROM of 10º or more was considered to be an impaired ROM. This cut-off point was chosen by experts working in the field of SCI. A limitation in shoulder ROM was therefore defined as a limitation of 10º or more in flexion, and/or external rotation and/or abduction in at least one shoulder.

Musculoskeletal pain of the shoulder. Subjects were asked in a standardized questionnaire if they had experienced pain in the shoulder joint or in the muscles around the shoulder since the last time of measurement (i.e. 3 months after starting active rehabilitation). Both shoulders were evaluated separately and musculoskeletal pain was scored as 0 when no pain was present or as 1 when pain was present in one or two shoulders (11).

Motor score – Functional Independence Measure (FIM). The FIM-Motor score consists of 13 items in 4 domains (self-care, continence, transfers and mobility). Each item can be scored from 1 to 7, where 1 = fully dependent and 7 = fully independent. The total score can therefore vary from 13 to 91 (12–13).

Wheelchair circuit. The total time of 2 time-dependent skills of the wheelchair circuit were chosen as outcome for our study (14–16). The time needed to perform a figure-of-8 shape and 15 m sprint were summed as outcome. Subjects with physical complications such as major shoulder pain or presence of pressure sores were excluded from the test.

Transferring oneself. We used the FIM motor score item on transferring to define our outcome. Based on expert opinion we dichotomized the outcome into 1 or 0, for "transfer independently" (FIM scores 5–7) and "transfer with assistance" (FIM scores 1–4), respectively (12).

Physical Activity Scale for Individuals with Physical Disabilities (PASIPD). The PASIPD was used to quantify the physical activity levels of our participants. The PASIPD is a self-report instrument (13) covering: (*i*) leisure activities, such as walking and wheeling outside the home, light, moderate, and vigorous sport and recreation activities, and exercise to increase strength and endurance; (*ii*) household activities, including light and heavy housework, home repair, lawn work, and outdoor gardening; and (*iii*) occupational activity. Two of these questions, lawn work or yard care, and outdoor gardening, were merged into a single question, because this represents the Dutch situation more adequately. The PASIPD total score is expressed in a metabolic equivalent is defined as the amount of oxygen required per minute under quiet resting conditions. The maximum score of this adapted version is 182.3 metabolic equivalents (16–17).

Statistical analyses

Shoulder ROM at discharge of rehabilitation was used as the independent variable in predictive models of the dependent variables of activities and participation one year after clinical rehabilitation. Total score of the Motor FIM, total time needed for the two wheelchair circuit items, ability to make an independent transfer and the total score of the PASIPD were selected as dependent variables (outcomes) for activities and participation. Possible confounders that were taken into account were SCI characteristics (level, completeness, time since injury), age, gender and shoulder pain, selected on the basis of previous literature and research (4–5, 7). If the limitation was greater than 10º the ROM was scored as limited (1), and if the limitation was less than 10º the ROM was scored as normal (0). The prevalence of impaired shoulder ROM was calculated separately for the total group and for subjects with tetraplegia at discharge because shoulder ROM is more prevalent in the latter group. Differences between subjects with limited shoulder ROM and without limited shoulder ROM regarding gender, age, level and completeness of injury, TSI, presence of shoulder pain and limitations of shoulder ROM were tested with the Student's t-test or the χ^2 test.

Secondly, to investigate the effect of limitations in shoulder ROM on activities and participation at one-year follow-up, the multi-level modelling programme MlwiN (MLwiN version 1.1; Centre for Multilevel Modelling, Institute of Education, London, UK) was used to correct for possible differences between study centres (18–19). In a first step, limitations in shoulder ROM (no limitation = 0; limitation = 1) was introduced in the basic model as independent variable. In a second step, personal characteristics (age, gender (men = 0; women = 1)), SCI characteristics (tetraplegia = 0; paraplegia = 1, incomplete = 0; complete = 1), TSI (months) and presence of shoulder pain (no = 0; yes = 1) were added to the basic model as possible confounding factors to define the final model. A factor added to the model was considered a confounder if adding that factor changed the beta of the model more than 10%. The regression coefficient for transferring oneself was converted to odds ratio (OR). An OR of 1 indicated that there was no association with this particular variable, an OR of less than 1 indicated an increased risk of not being able to transfer without assistance in the presence of a limited shoulder ROM, whereas an OR of greater than 1 indicated a decreased risk of being able to transfer without assistance in the presence of a limited shoulder ROM. The overall level of significance was $p < 0.05$. This analysis was performed for the total group ($n = 146$) and for the subjects with tetraplegia ($n = 52$).

RESULTS

Participant characteristics

The study population comprised 146 subjects, of whom 70% were male and 64% had paraplegia (Table I). Forty-nine percent ($n = 71$) of subjects were classified as American Spinal Injury Impairment Scale A (AIS A), 17% ($n = 25$) as AIS B, 19% ($n = 28$) AIS as C and 15% ($n = 22$) as AIS D. Thirty percent of the subjects ($n = 44$) had limited shoulder ROM. of which 42 subjects had limited shoulder flexion, 26 subjects had limited shoulder external rotation and 6 subjects had limited shoulder abduction.

The results of the FIM Motor score and ability to make a transfer were missing in 2 subjects.

The total score of the PASIPD was missing in 13 subjects, and performance time of the wheelchair circuit was missing in 33 subjects.

The t-test and χ^2 test showed that subjects with limited shoulder ROM at discharge more often had tetraplegia, had a longer duration of the injury and experienced more shoulder pain than those without limited shoulder ROM. Furthermore, they were less often able to transfer without help at 1 year after discharge, they scored a longer time on the wheelchair circuit items, and had a lower PASIPD score.

In the group of subjects with tetraplegia only, significant differences were also found between those with shoulder ROM limitations and without shoulder ROM limitations. Those with a limited shoulder ROM at discharge from initial rehabilitation had more shoulder pain at discharge. One year after discharge they were less often able to transfer without help, needed a longer time on the wheelchair circuit and had a lower PASIPD score.

Association of shoulder range of motion limitation at discharge with activities and participation one year later

Table II show the correlation between limited shoulder ROM at discharge and the FIM motor score, wheelchair circuit, PASIPD and transfer ability 1 year later for both total group and the persons with tetraplegia only. The table show both the basic models and the models after including confounding factors in the regression models. Significant relationships between ROM limitations and activities and participation were found in the basic models. In the total group and after correction for confounders, subjects with limited shoulder ROM had lower FIM motor scores, needed more time to complete elements of the wheelchair circuit, and were 5 times less likely to be able to perform an independent transfer. The correlation between limited shoulder ROM and the PASIPD was significant in the basic model, but was not significant taking into account the confounders.

For the subjects with tetraplegia, subjects with limited shoulder ROM had a significantly lower FIM motor score and were 10 times less likely than subjects without limited

Table I. *Patient characteristics: total group and subjects with tetraplegia including the* p-*value (using Student's* t-*test or* χ^2 *test) of the differences between groups. Level of significance:* $p < 0.05$

	Total group ($n = 146$)			Subjects with tetraplegia ($n = 52$)		
	Persons with ROM limitation ($n = 44$)	Persons without ROM limitation ($n = 102$)	p-value	Persons with ROM limitation ($n = 32$)	Persons without ROM limitation ($n = 20$)	p-value
Possible determinants at discharge						
Male gender, n (%)	31 (70)	72 (72)	0.913	21 (68)	16 (76)	0.852
Age, years, mean (SD)	43 (12)	39 (15)	0.173	41 (11)	38 (12)	0.531
Motor complete injury, n (%)	26 (60)	68 (69)	0.650	15 (48)	14 (67)	0.562
Tetraplegia, n (%)	31 (70)	21 (20)	0.001***	–	–	–
TSI (days), mean (SD)	411 (188)	279 (136)	0.005**	435 (204)	410 (202)	0.743
Shoulder pain, n (%)	26 (79)	31 (30)*	0.002**	18 (58)	7 (33)	0.443
Outcomes 1 year after discharge						
Total score on Motor FIM (range: 13–91), mean (SD)	48 (23)	70 (17)	<0.001***	44 (24)	59 (24)	0.0054
Time on Wheelchair Circuit (s), mean (SD)	34 (18)	18 (8)	<0.001***	39 (17)	23 (11)	0.001***
Total score on PASIPD (maximum score: 182.3), mean (SD)	12 (16)	21 (19)	0.021*	10 (15)	19 (26)	0.265
Ability to transfer without assistance, n (%)	18 (41)	84 (84)	<0.001***	10 (32)	14 (67)	0.077

*$p < 0.05$; **$p < 0.01$***$p < 0.001$.

ROM: range of motion; SD: standard deviation; PASIPD: Physical Activity Scale for Individuals with Physical Disabilities.

Table II. *Correlation of limitation of limited shoulder ROM at discharge with FIM motor score, wheelchair performance, PASIPD and transferring oneself 1 year later in the total study population (n = 146) and subjects with tetraplegia (n = 152). Level of significance: p < 0.05*

	Activity									Participation		
	FIM motor score (13–91)			WC Performance time			Transferring oneself			PASIPD (182.3)		
	Beta (SE)	95% CI	*p*-value	Beta (SE)	95% CI	*p*-value	Beta (SE)	OR	*p*-value	Beta (SE)	95% CI	*p*-value
Total group												
Basic model												
Constant	70.14 (1.89)			18.35 (1.28)			1.66 (0.27)			21.21 (1.92)		
Limited ROM	–22.49 (3.44)	–25.93, –12.45	<0.001	16.34 (2.34)	11.48, 20.93	<0.001	–1.99 (0.41)	0.1	<0.001	–8.98 (1.92)	–12.74, 5.22	<0.001
Model with confounders included												
Constant	78.99 (4.53)			14.9 (2.50)			4.01 (0.95)			26.00 (5.29)		
Limited ROM	–10.85 (3.39)	–17.49, –4.12	<0.001	10.10 (2.51)	5.18, 15.02	<0.001	–1.67 (0.57)	0.2	<0.001	–5.24 (4.03)	–13.14, 2.66	0.19
Age	–			–			–			–		
Gender	–			–			–			–		
Completeness	–			–			–1.98 (0.69)	0.1	<0.001	–		
Lesion level	8.28 (3.37)	1.63, 14.83	0.01	–5.42 (2.45)	–10.22, –0.62	0.03	1.24 (0.58)	3.5	0.03	–		
TSI	–1.65 (0.27)	–2.18, –1.12	<0.001	0.85 (0.21)	0.43, 1.26	<0.001	–0.14 (0.05)	1.5	0.01	–0.64 (0.33)	–1.28, 0.00	0.05
Shoulder pain	–			–			–0.16 (0.53)	0.9	<0.001	–		
Persons with tetraplegia only												
Basic model												
Constant	56.38 (5.44)			16.43 (4.27)			0.69 (0.46)			15.9 (4.08)		
Limited ROM	–14.28 (7.05)	–28.08,–0.48	0.04	9.93 (5.53)	–0.91, 20.77	0.07	–1.43(0.60)	0.02	0.02	–6.51 (5.28)	–16.35, 3.84	0.22
Model with confounders included												
Constant	73.65 (13.99)			21.90 (8.91)			4.59 (1.99)			31.20 (11.69)		
Limited ROM	–15.96 (6.36)	–28.43, –3.49	0.01	8.77 (5.57)	–2.51, 19.69	0.11	–0.97 (0.90)	0.1	0.03	–5.53 (5.41)	–16.31, 5.07	0.31
Age	0.56 (0.29)	0.00, 1.13	0.05	–			–			–		
Gender	–			–			–			–		
Completeness	–21.74 (6.40)	–34.28, –9.20	0.00	–			–2.35 (0.84)	0.1	0.01	–9.84 (5.13)	–19.90, 0.22	0.31
TSI	–1.17 (0.48)	–2.11, –0.23	0.01	–			–			–0.11 (0.06)	–0.23, 0.01	0.05
Shoulder pain	–			10.69 (5.39)	0.13, 21.25	0.05	–			–		

ROM: range of motion; FIM: Functional Independence Measure; PASIPD: Physical Activity Scale for Individuals with Physical Disabilities; WC: Wheelchair Circuit; TSI: time since injury; SE: standard error; 95% CI: 95% confidence interval; OR: odds ratio.

shoulder ROM to be able to perform an independent transfer. No significant associations between shoulder ROM limitation and time needed for the wheelchair circuit and the PASIPD score were found in subjects with tetraplegia.

DISCUSSION

This study showed that persons with a SCI and limited shoulder ROM at discharge performed worse on activities 1 year later, as measured with the FIM motor score, the ability to make a transfer independently and the time needed to complete the wheelchair circuit. This correlation was not found in subjects with tetraplegia. No significant correlation was found in persons with a SCI and limited shoulder ROM and participation, as measured with the PASIPD.

Our results confirm the findings of Ballinger et al. (4), who showed that subjects with chronic SCI and a limitation in shoulder ROM were more likely to need maximal assistance for transfers and reported a lower FIM score. Our study, however, not only analysed the total group, but analysed those with tetraplegia separately, and included wheelchair circuit items as an outcome on activity and the PASIPD as outcome on participation. The study of Salisbury et al. (5) on shoulder pain, ROM, and functional motor skills after acute tetraplegia in 41 subjects measured during inpatient rehabilitation, first within 1 week after admission and secondly at discharge, was inconclusive. Their outcomes were not clearly defined, and statistical analyses of the correlation between the effect of shoulder ROM and these outcomes of functioning were not described in their study. In our study we defined the outcomes clearly and focused on the highly important period between discharge and the first year after discharge. As stated previously, this period is characterized by utilizing skills learned in inpatient rehabilitation for activities and participation in everyday life in the home environment.

No correlations between limitations in shoulder ROM and PASIPD total scores were found. A possible reason for this is that the PASIPD score is more strongly influenced by other factors; for example, having an adapted car or the person's motivation to be physically active. In both the total group and those the subjects with tetraplegia we found a significant difference in time needed for the wheelchair circuit between those with and without limited shoulder ROM. However, after controlling for confounding factors we found a significant correlation between a limited shoulder ROM and time needed for the wheelchair circuit items only in the total group. One explanation for this outcome might be the smaller sample size of the subgroup of subjects with tetraplegia. Another explanation might be that other confounding factors, for example the level of the SCI, for which we did not control in this subgroup, could have a significant relevance in this group. In our study population a higher level of injury was associated with longer time needed to complete the items of the wheelchair circuit, but sample size for each individual level of injury was too small to perform analyses.

We have shown in the current study that, in persons with SCI (persons with paraplegia and tetraplegia), limited shoulder ROM at discharge is related to limitations in their daily activities as measured with the FIM, in transferring and for the total group in the performance time on a figure-of-8 shape and the 15-m sprint. Discharge is a milestone during rehabilitation; it is the transition to the home situation, where all learned skills (abilities) are to be implemented in daily practice (performance). Based on the person's functioning during initial inpatient rehabilitation a prediction of a person's functioning in the day-to-day situation is made. Based on this evaluation, home care, AT and interventions (for example physiotherapy) are organized. Our study showed that persons with limited shoulder ROM at discharge perform worse on activities, and that it is possible to detect at discharge from initial rehabilitation those persons at risk. These findings are relevant for rehabilitation, in the organization of care, AT and interventions, and for future research.

Limitations and future studies

One of the inclusion criteria for the study was that subjects had to be (mainly) wheelchair-dependent. Although one can assume that shoulder ROM limitations affect wheelchair-dependent persons most, this limits the external validity of the study to those subjects who are mainly walking for their mobility.

Although 146 persons with SCI were included in our study, the number of participants is limited, especially for analysis in the group with tetraplegia. For this study we could only use the data of those subjects who were measured at discharge as well as 1 year later. For several reasons 23 subjects were lost to follow-up. The wheelchair performance items in particular had missing data. Subjects with complications, such as major shoulder pain or pressure sores, were excluded for this item. Although this is inevitable in a study in subjects with SCI, it lowers the number of subjects in the analysis. This makes it particularly difficult to substantiate an association between shoulder ROM, activities and participation in persons with tetraplegia, because of the limited number of confounders that can be put into the multilevel regression model. We therefore might not have included all possible confounders in this study.

This study showed a correlation between limited shoulder ROM at discharge and performing worse on activities 1 year later, but did not show a causal relationship. Future studies should focus on the influence of methods preventing shoulder ROM limitations in order to reflect causality.

In conclusion, persons with a SCI with limited shoulder ROM at discharge from initial clinical rehabilitation are more limited in their activities 1 year after discharge.

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