Spinal Cord (2011) 49, 416–420

www.nature.com/sc

ORIGINAL ARTICLE

The timing and achievement of mobility skills during SCI rehabilitation

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Study design: Retrospective, observational study, with consecutive sampling.
Objectives: To document the frequency and time frames for the achievement of independence in mobility skills for people undergoing rehabilitation following spinal cord injury (SCI).
Setting: The South Australian Spinal Cord Injury Service, Hampstead Rehabilitation Centre, Adelaide, Australia.
Methods: Retrospective data collection from a purpose-designed form. The achievement of independence in nine functional mobility skills, and time lines for this, were documented for people with a new SCI undergoing rehabilitation. Data from 152 participants were analyzed.
Results: Of the nine mobility-based goals evaluated, the one most likely to be achieved was sitting on the edge of the bed and the least likely was gait. Time taken to achieve the skills varied from 4 to 10 weeks on average and reflected the degree of difficulty.
Conclusion: The frequency and time frames to achieve independence in mobility skills documented in this study will be useful when goal setting in a post-acute SCI rehabilitation setting.
Spinal Cord (2011) **49,** 416–420; doi:10.1038/sc.2010.148; published online 26 October 2010

Keywords: spinal cord injuries; rehabilitation; recovery of function; physical therapy (specialty); physical therapy modalities; motor skills

Introduction

Rehabilitation programs are essential in providing people with SCI with the skills and knowledge required to function at an increased level of independence within their communities. In this rehabilitation process, it is important to be able to chart progress through the recovery pathway and to have predictors of milestones—this includes the type of milestone, the likelihood of achievement, the sequence of attainment and the time taken to achieve. This is useful for service planning and for individual goal setting and monitoring.

The Consortium for Spinal Cord Medicine[1] has published clinical practice guidelines regarding expected neurological recovery, including impairment, activity and participation domains following spinal cord injury (SCI). These guidelines were developed by an expert panel and were based on extensive and detailed reviews of published international literature. With regard to motor recovery, the Consortium for Spinal Cord Medicine[1] stated that one-half to two-thirds of motor recovery following incomplete SCI will occur within the first 2 months after injury and that motor recovery will slow after the first 3 to 6 months after initial injury.

Several studies have been conducted, which examine broad outcomes following SCI as a measure of the effectiveness of the entire rehabilitation process. Bode and Heinemann[2] reported that persons with higher functional status at admission will generally have a shorter length of stay in rehabilitation and greater rate of improvement. This is supported by Cripps[3] who stated that in the Australian context, the median duration of initial care for those people with tetraplegia, and therefore a lower functional status at admission, is on average 58% longer than that of people presenting with paraplegia. This suggests that initial indicators of functional status such as neurological level of SCI should be able to assist in predicting the length of stay in rehabilitation and rate of functional improvement.

Another study by Jongjit *et al.*,[4] which investigated the functional outcomes of 38 people presenting with traumatic SCI, found that participants with complete tetraplegia had a longer mean length of stay in hospital than participants presenting with complete paraplegia or incomplete injuries. In addition, they found that all participants demonstrated significant progress towards independence in each of the six activities of daily living assessed, including those with complete injuries. Those participants presenting with

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Received 2 July 2010; revised 16 September 2010; accepted 17 September 2010; published online 26 October 2010

incomplete injuries were generally shown to have higher overall independence scores, indicating better functional outcomes following rehabilitation after SCI.[4] Interestingly though, participants with incomplete paraplegia were shown to have more difficulty with self-care activities and sphincter control than any of the other subgroups studied, and those with complete paraplegia also did not meet the expected outcomes of maximal independence in the activities of dressing, bladder and bowel management, mobility and locomotion.[4] However, because of the small sample size for the overall study, and consequently even smaller participant numbers in each individual injury classification group, these results must be considered with caution.

The studies and reports discussed above indicate that all people with SCI improve their independence in a variety of functional tasks to some degree during rehabilitation and that this varies widely depending on the neurological level and extent of injury to the spinal cord. However, although these studies have investigated broad functional outcomes in terms of self-care and mobility tasks, there appear to be no published studies, which have specifically examined the or frequency of achievement, time frames for the achievement of physiotherapy functional skills, which are predominantly mobility-based, in people undergoing rehabilitation following SCI.

This paper will report on the specific research questions:

1. What is the frequency of achievement of mobility-based functional skills for people undergoing rehabilitation following SCI?
2. What are the time frames for the achievement of mobility-based functional skills for people undergoing rehabilitation following SCI?

Subjects and methods

This study used a retrospective, observational, consecutive sample design to examine mobility-based outcomes for people undergoing rehabilitation following acute SCI. Ethical approval was granted by the Royal Adelaide Hospital Research Ethics Committee and the University of South Australia Divisional Human Research Ethics Committee.

Participants

All people consecutively admitted to the South Australian Spinal Cord Injury Service (SASCIS) at Hampstead Rehabilitation Centre (HRC) over a 3-year period (2000–2003), were considered; those presenting with acute SCI and undergoing their primary period of rehabilitation at the SASCIS unit were included in the study. People were excluded if they had a primary diagnosis other than acute SCI, or if they had been (re) admitted for other reasons such as management of pressure areas, review of function or equipment or after surgery. People were withdrawn from the study if their physiotherapy records were incomplete or if they did not complete their rehabilitation at the SASCIS.

Setting

People with SCI are transferred from the acute setting (Royal Adelaide Hospital) to the SASCIS rehabilitation unit when they are determined to be medically stable and ready for rehabilitation. For this study, if the formal rehabilitation program was commenced elsewhere before transfer (that is, other than the SASCIS HRC unit) they were excluded. The SASCIS rehabilitation unit is a 25-bed in-patient ward with 3.4 full-time equivalent physiotherapists present at the time of this study. Standard rehabilitation in the SASCIS unit consists of an hour of gym-based physiotherapy per weekday, supplemented by an hour of hydrotherapy up to three times per week, as appropriate. Physiotherapy sessions are generally on one-to-one basis with an additional help from physiotherapy assistants as required. Daily physical education and occupational therapy sessions (usually also an hour per session) also occur as indicated.

Data collection

Data regarding the injury type, mechanism and classification/s (such as American Spinal Injury Association (ASIA) impairment scale scores) were obtained from the central Australian SCI register and from individual physiotherapy records. Neurological level of injury was used to classify participants into clinically meaningful groups to allow for comparison of outcomes data, and was based on the groups described by Woolsey[5] (Table 1). Other domains of interest such as functional independence measure scores (FIM) and length of stay were also recorded from the medical records to be able to further describe the sample.

Participants were then further grouped based on their ASIA impairment classification and those with ASIA A, B and C classifications were combined. Ideally participants with ASIA C impairments should be considered separately with those with ASIA A and B impairments, however this was not carried out as it would have resulted in smaller participant numbers within each injury classification group.

Mobility-based skill

Nine skills routinely taught by physiotherapists in rehabilitation following SCI were used as outcome measures for this study. Operational definitions for each skill are provided in Table 2. These data were all routinely recorded on the physiotherapy clinical pathway recording document already in use within the SASCIS Physiotherapy Department at HRC. Whether or not participants achieved independence with each of the nine skills described in Table 2 and the time taken for each participant to do so was recorded. This was documented as the number of weeks post admission to HRC, not the number of weeks post injury.

Table 1 Classification by neurological motor level of injury as described by Woolsey[5]

Neurological classification	*Definition*
High tetraplegia	Injury level C4 and C5
Middle tetraplegia	Injury level C6
Low tetraplegia	Injury level C7 and C8
High paraplegia	Injury level T1–T6
Middle paraplegia	Injury level T7–L1
Low paraplegia	Injury level L2 and below

Table 2 Operational definitions of observed mobility-based skills

Skill	*Definition*
Bed mobility	The ability to roll to both right and left sides, move from lying to sitting and lift legs on and off a soft double bed.
Long-sit balance	The ability to maintain one's balance safely both statically and during dynamic activities[a], while sitting with legs up on a soft double bed.
High-sit balance	The ability to maintain one's balance safely both statically and during dynamic activities[a], while sitting on the edge of a soft bed with feet positioned flat on the floor.
Bed to wheelchair transfer	The ability to transfer safely between a soft bed from a wheelchair and return.
Shower to chair transfer	The ability to transfer safely between a soft bed and a mobile shower chair and return, or between a wheelchair and a static shower chair and return.
Toilet transfer	The ability to transfer safely between a wheelchair and a toilet and return.
Car transfer	The ability to transfer safely between a wheelchair and the front passenger seat of a standard motor vehicle and return.
Floor transfer	The ability to transfer safely from a wheelchair to the floor and return.
Gait	The ability to ambulate with or without gait aids.

[a]Static versus dynamic activities distinguishes between the task of simply maintaining the position (static) versus performing tasks within the action of position maintenance such as reaching, dressing and so on (dynamic).

If independence was not reached with a particular skill then it was recorded as not achieved. For a participant to be deemed as independent they had to be able to perform each component of the skill being assessed without physical assistance, supervision or verbal cues/instructions from another person or therapist. In addition, if a skill would not normally be attempted with a particular individual then it was recorded as not applicable. An example of this might be floor transfers for a person with complete high-level tetraplegia.

Data management

Raw data were entered into Microsoft Excel spreadsheets and data analysis was undertaken using the SPSS statistical software package (SPSS for Windows, SPSS Inc., Chicago, IL, USA). Summary descriptive statistics (for example, frequencies, means, s.d. and ranges) were calculated for demographic and background data. Frequency of achievement, and means, s.d.'s and ranges for time frames for skill achievement were calculated for each of the physiotherapy skills investigated, first for the sample as a whole, and subsequently for each of the injury classification groups.

Results

Participants

A total of 152 participants admitted to SASCIS during the study period were eligible for inclusion in the study. Table 3 summarizes the basic descriptive data of the cohort in the paraplegia and tetraplegia categories, as well as the cause of the SCI and length of stay in both the acute and rehabilitation phases.

Table 3 Baseline characteristics of 150 participants[a]

	Tetraplegia (n = 59)	*Paraplegia* (n = 91)
Sex, n males (%)	44 (75)	73 (80)
Age (yr), mean (s.d.)	45 (18.4)	48 (19.9)
Cause, n (%)		
Traumatic	50 (85)	44 (48)
Non-traumatic	9 (15)	47 (52)
LOS (days), mean (s.d.)		
Acute hospital	41 (36.3)	39 (51)
Rehabilitation center	142 (118.4)	104 (82)
Total	184 (134.8)	144 (101.4)

Abbreviations: LOS, length of stay; n, number; SCI, spinal cord injury; s.d., standard deviation; yr, years.
[a]Level and severity of SCI were unavailable for two participants, hence their baseline data are missing from this table.

A total of 217 participants were excluded from the study, with the majority excluded because the participants were readmissions to the unit because of problems relating to a preexisting SCI ($n = 141$, 65%). Of these 141 excluded participants, most were either readmitted for the management of pressure areas and commencement of a sitting program ($n = 39$, 28%), or for the management of bowel/bladder issues ($n = 23$, 16%). Other reasons for exclusion were those with non-SCI diagnosis ($n = 22$), incomplete records ($n = 21$), rehabilitation completed elsewhere ($n = 23$), whereas four died and six were excluded for 'other reasons'. Two patients commenced their rehabilitation elsewhere.

Functional independence measure

Figure 1 outlines the FIM scores on admission to, and discharge from, rehabilitation for participants within each of the 10 different injury classification groups. The change in FIM score from admission to discharge is also shown. With regard to the change in FIM score, those in the high tetraplegia A–C group showed the lowest mean FIM change score of only 22 points.

Achievement of mobility-based skills

Table 4 summarizes the frequency and percentage of people who achieved the defined mobility-based skills. The achievement levels are broken down into injury classifications. It can be seen that there is a clear pattern for the rate of achievement to be higher in all ASIA D classifications irrespective of injury level. This notwithstanding, lower levels of injury resulted in higher frequencies of achievement. There is also a hierarchy of skill achievement across the board, with gait being the least likely skill to be achieved and high sitting the most likely.

Time taken to achieve independence in mobility-based skills

Table 5 summarizes the time taken to achieve the mobility-based skills according to each injury classification. The category D participants achieved these goals in the shortest time frames across the levels, whereas lower the injury level

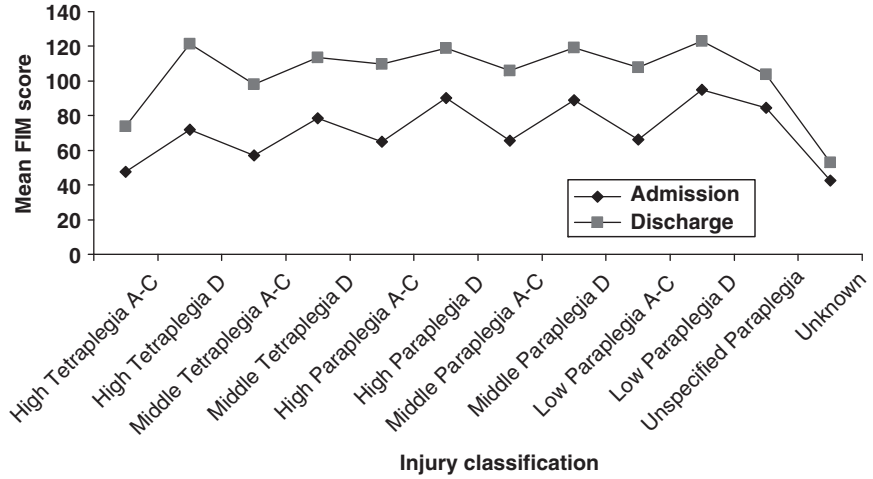

Figure 1 Mean functional independence measure scores according to injury classification.

Table 4 Frequency and percentage of achievement of independence in mobility-based skills in each injury category

Injury category	n	*Long-sit balance*	*High-sit balance*	*Bed mobility*	*Bed to wheelchair transfers*	*Shower to chair transfers*	*Toilet transfers*	*Car transfers*	*Floor transfers*	*Gait*
Tetraplegia	**59**	**33 (56%)**	**41 (70%)**	**40 (69%)**	**39 (66%)**	**38 (64%)**	**36 (61%)**	**36 (61%)**	**29 (49%)**	**31(52%)**
High T A–C	27	8 (30%)	11 (41%)	10 (37%)	10 (37%)	9 (33%)	7 (26%)	8 (30%)	5 (19%)	6 (22%)
High D	21	16 (76%)	21 (100%)	21 (100%)	21 (100%)	21 (100%)	21 (100%)	20 (95%)	18 (86%)	18 (86%)
Middle A–C	6	5 (83%)	4 (67%)	4 (67%)	4 (67%)	4 (67%)	4 (67%)	4 (67%)	3 (50%)	3 (50%)
Middle D	5	4 (80%)	5 (100%)	5 (100%)	4 (80%)	4 (80%)	4 (80%)	4 (80%)	3 (60%)	4 (80%)
Paraplegia	**91**	**81 (89%)**	**87 (96%)**	**83 (91%)**	**73 (80%)**	**69 (76%)**	**64 (70%)**	**65 (71%)**	**39 (43%)**	**34 (37%)**
High A–C	19	18 (95%)	18 (95%)	17 (90%)	15 (79%)	13 (68%)	12 (63%)	13 (68%)	4 (21%)	1 (5%)
High D	4	4 (100%)	4 (100%)	4 (100%)	3 (75%)	3 (75%)	3 (75%)	3 (75%)	3 (75%)	3 (75%)
Middle A–C	37	35 (95%)	35 (95%)	32 (87%)	27 (73%)	26 (70%)	22 (60%)	24 (65%)	15 (41%)	10 (27%)
Middle D	9	6 (67%)	8 (89%)	9 (100%)	9 (100%)	9 (100%)	9 (100%)	9 (100%)	5 (56%)	7 (78%)
Low A–C	6	6 (100%)	6 (100%)	5 (83%)	5 (83%)	5 (83%)	4 (67%)	4 (67%)	3 (50%)	4 (67%)
Low D	9	7 (78%)	9 (100%)	9 (100%)	9 (100%)	9 (100%)	9 (100%)	8 (89%)	6 (67%)	9 (100%)
Unspecified	7	5 (71%)	7 (100%)	7 (100%)	5 (71%)	4 (57%)	5 (71%)	4 (57%)	3 (43%)	—
Unknown	2	1 (50%)	1 (50%)	—	—	—	—	—	—	—
Total	**150**	**114 (76%)**	**128 (85%)**	**123 (82%)**	**112 (75%)**	**107 (71%)**	**100 (67%)**	**101 (67%)**	**68 (45%)**	**65 (43%)**

faster is the time to achievement. It should be noted that these times are reported in weeks from admission to the SASCIS rehabilitation unit, and that the mean length of stay for the acute hospital admission needs to be added to give time since injury to skill attainment. Time to achieve safe and independent gait was not recorded.

Discussion

Although current literature has examined broad outcomes following SCI rehabilitation, this study is the first that has investigated the achievement of specific physiotherapy outcomes following SCI and time frames for these. A clearer understanding of these pathways will enable physiotherapists working in SCI rehabilitation to more easily determine appropriate and realistic rehabilitation goals for individual people with SCI. This will then assist in improving the efficiency and effectiveness of physiotherapy interventions provided in rehabilitation following SCI, and will also enhance discharge planning and goal-setting processes. These processes are important to ensure that rehabilitation programs are meeting their desired aims with regard to maximizing functional independence following SCI.

Our findings are in agreement with those of the Consortium for Spinal Cord Medicine (2002) in terms of their general time frames and broad levels of SCI. For example, they reported that people with SCI at the levels between T1 and S5 should achieve independent bed mobility; that levels from C7 to C8 may achieve independent bed mobility; C5 to C6 levels will require some assistance and C1 to C4 levels will require total assistance. Similarly the Consortium reported that for transfers, people with T1–S5 levels should achieve total independence for all transfers (even and uneven); C7 to C8 levels should be independent for even transfers but may require some assistance for uneven transfers; C6 level may be independent for even, but will require some to total assistance for uneven transfer and the levels from C1 to C5 will require total assistance for both. Our data allow for a more precise consideration of the achievement, and time frames of achievement, of individual transfers across the major injury classifications. Furthermore, we can confirm that people with incomplete

Table 5 Time to achieve independence in mobility-based skills in each injury category, reported as mean number of weeks (s.d.) and range in weeks

Injury category	n	*Long-sit balance*	*High-sit balance*	*Bed mobility*	*Bed to wheelchair transfers*	*Shower to chair transfers*	*Toilet transfers*	*Car transfers*	*Floor transfers*
Tetraplegia	**59**	**4.5 (4.9) 1–17**	**5.3 (10.7) 1–62**	**7 (11) 1–67**	**7.8 (9.4) 1–48**	**7 (6.8) 1–27**	**6.1 (5.5) 1–22**	**7.1 (6.8) 1–28**	**6.8 (4.1) 1–18**
High T A–C	27	5.1 (4.6) 1–14	12 (18.6) 1–62	14.4 (19.6) 1–67	14.9 (15) 1–48	11.6 (9.8) 1–27	7.7 (7.4) 1–22	10.8 (9.6) 1–28	9 (6.7) 1–18
High D	21	3.1 (3.5) 1–10	2.1 (2.1) 1–10	3.9 (2.7) 1–10	4.8 (3.8) 1–15	5 (4) 1–15	4.9 (3.8) 1–15	5.15 (4.2) 1–19	6.1 (3.8) 1–13
Middle A–C	6	7.8 (8) 1–17	5 (7.4) 1–16	5.5 (6.6) 1–15	7.8 (7) 2–18	8 (7) 2–18	8.8 (8.4) 2–21	9.5 (9.9) 2–24	7.7 (2.9) 6–11
Middle D	5	4.5 (5.1) 1–12	4.6 (7) 1–17	6.2 (8) 1–19	6 (8) 1–18	6.5 (7.7) 2–18	7 (7.4) 3–18	7.5 (7.19) 2–18	6.3 (0.6) 6–7
Paraplegia	**91**	**4.7 (4.3) 1–18**	**3.6 (3.5) 1–14**	**5.1 (4.8) 1–22**	**7.6 (7.6) 1–42**	**8.6 (9.3) 1–43**	**7.6 (7.5) 1–44**	**9 (7.5) 1–43**	**10 (8.4) 1–43**
High A–C	19	5.6 (4.3) 1–17	6.1 (4.1) 1–14	7.8 (5.7) 1–18	13.1 (7.6) 1–27	15 (10.6) 2–42	16 (11) 5–44	13.9 (6) 6–23	15.8 (5.7) 11–24
High D	4	1.8 (0.5) 1–2	1 (0.0) —	1.5 (1) 1–3	2.3 (1.5) 1–4	2.3 (1.5) 1–4	2.3 (1.5) 1–4	2.7 (1.2) 2–4	3.3 (2.3) 2–6
Middle A–C	37	5.2 (4.7) 1–18	4.1 (3.6) 1–14	5.8 (4.6) 1–22	8.9 (8.1) 1–42	9.8 (8.3) 1–42	8.3 (5.2) 1–20	11.3 (9.1) 2–43	14.7 (9.5) 5–43
Middle D	9	3.3 (3.1) 1–9	1.9 (1.7) 1–6	2.8 (2.7) 1–8	3.7 (2.7) 1–9	3.7 (2.7) 1–9	3.8 (2.6) 1–9	5.6 (3.7) 1–11	4.2 (1.9) 1–6
Low A–C	6	4.8 (4.2) 1–10	2 (1.6) 1–5	5 (4.9) 1–13	7.6 (9.9) 1–25	12.4 (17.4) 1–43	6.3 (6) 1–14	8 (5.7) 3–16	7 (5.3) 3–13
Low D	9	1.4 (0.5) 1–2	1.2 (0.4) 1–2	1.4 (1.3) 1–5	2.3 (1.7) 1–6	2.3 (1.7) 1–6	2.3 (1.6) 1–6	3.1 (2.5) 1–9	4.8 (3.7) 2–10
Unspecified	7	5.8 (6.1) 1–16	2.4 (1.8) 1–5	4.4 (5) 1–13	3.8 (3.7) 1–10	2.8 (1.5) 1–4	4.6 (3.6) 1–10	4.5 (3.3) 1–9	8.7 (10.8) 1–21
Unknown	2	4.0 (0.0) —	1.0 (0.0) —	—	—	—	—	—	—

SCI lesions, irrespective of level, attain these goals more often and more rapidly.

A decision for earlier than usual discharge may have influenced the opportunity for people to achieve the defined mobility skills in the data collection period. If discharge occurred prematurely, that is to say rehabilitation was not considered complete, these participants were then excluded from the analysis. However it is possible that with a longer data collection period (beyond discharge) more people may achieve independence in the studied mobility skills.

Our data support the inherent hierarchy of difficulty in the nine mobility tasks; confirming that the task demands increase from basic sitting through to increasingly complex transfers and finally walking. This was demonstrated by a decreasing frequency of achievement and an increasing time to achieve as the spectrum of skills increased in difficulty.

We are confident that our data are accurate given the sample size (152) and that this sample is representative of people with SCI in Australia; given we were able to capture the majority of new cases because SASCIS at HRC is the only unit in this state to offer SCI rehabilitation. Our data should also be applicable to other countries in which the prevalent causes, demographics and management of SCI are similar. Rehabilitation provision by physiotherapists in the HRC unit is considered standard and therefore comparable to other sites nationally and internationally.

Conclusion

This study gives a first approximation of the likelihood of people with SCI first achieving mobility-based skills and second the possible time frames—all according to level and completeness of their injury. These data will give clinical physiotherapists and other members of the multidisciplinary team a guide to goal setting and service provision.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

We acknowledge Sue Winkler, Physiotherapist, Ruth Marshall, Medical Director SASCIS and the clinicians who recorded the initial data and the people with SCI attending rehabilitation.

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