Relationships Between Specific Functional Abilities and Health-Related Quality of Life in Chronic Traumatic Spinal Cord Injury

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Objective: The objective of this study was to explore the relationships between specific functional abilities assessed from the third version of the Spinal Cord Injury Measure and health-related quality of life after a traumatic spinal cord injury.

Design: A prospective cohort of 195 patients who had sustained a traumatic spinal cord injury from C1 to L1 and consecutively admitted to a single level 1 spinal cord injury–specialized trauma center between April 2010 and September 2016 was studied. Correlation coefficients were calculated between Spinal Cord Injury Measure scores and Short Form 36 version 2 summary scores (physical component score; mental component score).

Results: The total Spinal Cord Injury Measure score correlated moderately with the physical component score in the entire cohort, correlated strongly with physical component score in tetraplegics, did not correlate with physical component score in paraplegics, and did not correlate with mental component score. Mobility subgroup and individual items scores showed the strongest correlations with the physical component score in the entire cohort, followed by self-care and sphincter management.

Conclusions: This work is significant being the first to determine which specific functional abilities are mostly related to health-related quality of life and highlights the differences between tetraplegic and paraplegic patients. Our findings could help clinicians to guide rehabilitation plan based on importance of specific functional abilities in relationship with the health-related quality of life.

Key Words: Spinal Cord Injury, Health-Related Quality of Life, Functional Abilities

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Traumatic spinal cord injury (TSCI) is a debilitating condition that creates a plethora of challenges to the patient, their support system, and society. It implies many different levels of long-term disability, which require significant adaptation because people with spinal cord injury often see their life change substantially after the trauma. It involves considerable costs and efforts from all parties involved.[1] To adequately measure improvements in care regarding life satisfaction in this population, there has been much interest toward quality-of-life (QoL) research in the recent years.[2,3] Health-related QoL (HRQoL) is considered a useful tool in TSCI research because it encompasses many dimensions focusing on health that are important to consider when evaluating progress and responses to interventions.[4]

In addition, there are still controversies regarding long-term priorities of patients with a TSCI. Simpson et al.[5] suggested in a systematic review that the two health priorities cited as most important by patients were motor function and bowel/bladder function, whereas Lo et al.[6] found that arm function, bowel/bladder function, and walking were the most important. Similarly, Manns et al.[7] observed that physical function and independence were highly associated with the QoL of patients. Although these studies emphasized on understanding which general life domains are prioritized by patients, they mainly rely on a subjective assessment of patients.

Alternatively, other authors have assessed the impact of function impairment using validated objective measures of function, on QoL or health/life satisfaction. Accordingly, different authors have observed positive associations with the motor subscale of the Functional Independence Measure,[8–11] Functional Independence Measure total score,[12] Barthel Index,[13] and a total score of the third version of the Spinal Cord Independence Measure (SCIM-III).[1,14] Unfortunately, these studies did not look into which specific functional abilities would be mostly related to patient's QoL, despite the use of validated questionnaires involving multiple items specifically assessing multiple aspects of the functional status. Further analysis in this direction would be significant because it would guide clinicians to better elaborate patient's treatment and rehabilitation plan.

Therefore, this study aims at objectively exploring the relationships between specific functional abilities for performing activities of daily living independently, based on the SCIM-III questionnaire, and HRQoL as assessed by the Short Form 36 version 2 (SF-36v2) after a TSCI.

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MATERIAL AND METHODS

Patients

A prospective cohort of 195 patients sustaining a TSCI and consecutively admitted to a single level 1 SCI-specialized trauma center between April 2010 and September 2016 was studied. All patients were recruited on a voluntary basis at time of admission and were followed after discharge from the trauma center. They were included if they sustained an acute TSCI with a neurological level of injury between C1 and L1 that required surgical management in our institution. They were included if they were 17 yrs or older and they presented to the follow-up visit between 6 and 12 mos after injury. Exclusion criteria were the following: (1) penetrating trauma causing the spinal cord injury, (2) absent or incomplete functional and QoL assessment between 6 and 12 mos after the injury, and (3) neurological level below L1, excluding lower motor neuron injuries to evaluate a subgroup of similar patients with respect to the type of neurological injury. The study was approved by the institutional review board. All patients provided written informed consent to be included in the study. This study conforms to all STrenghtening the Reporting of OBservational studies in Epidemiology guidelines and reports the required information accordingly (see Checklist, Supplemental Digital Content 1, http://links.lww.com/PHM/A642).

Data Collection

Sociodemographic and clinical data were retrieved from our institution's SCI prospective database to describe the total cohort of patients. Collected data are shown in Table 1 and included age, sex, initial grade of severity of neurological deficits, neurological level of injury (tetraplegia from C1 to C8, paraplegia from T1 to L1), mechanism of injury (sports, fall, motor vehicle accident, other), trauma severity (measured by the Injury Severity Score), surgical delay between trauma and surgery (dichotomized as <24 hrs or >24 hrs after trauma), presence of concomitant traumatic brain injury, length of stay in acute care facility, and discharge destination after acute care (home, intensive functional rehabilitation, or others). The neurological examination was performed according to the International Standards for Neurological Classification of Spinal Cord Injury,[15] to determine the American Spinal Injury Association impairment scale grade and the neurological level of injury.

Functional status and HRQoL questionnaires were administered at the same moment during routine follow-up visit between 6 to 12 mos after the trauma. Functional status was assessed by the SCIM-III that evaluates the level of independence in 19 different items related to activities of daily living (Table 2). The 19 items are separated in the following three areas of function: self-care (feeding, grooming, bating, and dressing; subscore = 0–20), respiration and sphincter management (subscore = 0–40), and mobility (bed and transfers, indoor/outdoor ambulation; subscore = 0–40). The total SCIM-III score can reach 100, where higher scores correspond to higher levels of independence. The SCIM-III is a valid and reliable questionnaire that showed higher specificity with regard to TSCI.[16]

Health-related QoL was assessed by the SF-36v2 questionnaire in which reliability and validity have also been demonstrated in the TSCI population.[17] The SF-36v2 consists of 36 items assessing the following eight distinct health domains: (1) physical functioning, (2) role physical, (3) body pain, (4) general health, (5) vitality, (6) social functioning, (7) role emotional, and (8) mental health.[18] The physical component score (PCS) and the mental component score (MCS) derived from the weighted eight health domains were calculated

TABLE 1. Sociodemographic and clinical characteristics of the cohort of patients with a traumatic spinal cord injury

		All Patients	Tetraplegic	Paraplegic
n		195	127	68
Age	Mean (SD)	48.8 (18.0)	52.7 (17.7)	41.9 (16.5)
Sex	Male, %	79.7	78.1	82.4
Initial AIS grade	A, %	35.6	22.7	60.3
	B, %	9.6	10.2	7.4
	C, %	14.2	17.1	8.8
	D, %	40.6	50.0	23.5
Mechanism of injury	Sports, %	16.8	16.4	16.2
	Fall, %	45.2	46.9	42.6
	MVA, %	27.9	28.1	27.9
	Other, %	10.1	8.6	13.3
ISS	Mean (SD)	22.9 (8.9)	21.5 (9.1)	25.7 (7.7)
Surgical delay	<24 hrs, %	46.6	37.6	63.2
Traumatic brain injury	Presence, %	50.0	56.1	60.3
LOS HSCM	Mean (SD)	25.7 (18.0)	26.7 (19.9)	24.2 (13.7)
Discharge destination	Home, %	15.7	19.5	8.8
	IFR, %	77.2	71.9	86.8
	Other, %	7.1	8.6	4.4

AIS, American Spinal Injury Association impairment scale grade; HSCM, Hôpital du Sacré-Coeur de Montréal; IFR, intensive functional rehabilitation; ISS, Injury Severity Score; LOS, length of stay; MVA, motor vehicle accident.

TABLE 2. The SCIM-III items and description

1	Feeding (cutting, opening containers, pouring, bringing food to mouth, holding cup with fluid)
2 A	Bathing upper body (soaping, washing, drying body and head, manipulating water tap)
2 B	Bathing lower body (soaping, washing, drying body and head, manipulating water tap)
3 A	Dressing upper body (clothes, shoes, permanent orthoses; dressing, wearing, undressing)
3 B	Dressing lower body (clothes, shoes, permanent orthoses; dressing, wearing, undressing)
4	Grooming (washing hands and face, brushing teeth, combing hair, shaving, applying makeup)
5	Respiration
6	Sphincter management - bladder
7	Sphincter management - bowel
8	Use of toilet (perineal hygiene, adjustment of clothes before/after, use of napkins or diapers)
9	Mobility in bed and action to prevent pressure sores
10	Transfers: bed-wheelchair (locking wheelchair, lifting footrests, removing and adjusting arm rests, transferring, lifting feet)
11	Transfers: wheelchair-toilet-tub (if uses toilet wheelchair: transfers to and from; if uses regular wheelchair: locking wheelchair, lifting footrests, removing and adjusting armrests, transferring, lifting feet)
12	Mobility indoors
13	Mobility for moderate distances (10–100 meters)
14	Mobility outdoors (>100 meters)
15	Stair management
16	Transfers: wheelchair-car (approaching car, locking wheelchair, removing arm and footrests, transferring to and from car, bringing wheelchair into and out of car)
17	Transfers: ground-wheelchair

for all patients included in the analysis. These summary scores have been widely used in the past to assess the HRQoL of patients with TSCI.[2]

Statistical Analysis

Descriptive statistics were used to outline the characteristics of the population. Continuous data were described using means and standard deviations, whereas percentages and proportions were used for categorical data. The relationship between the functional performance and QoL scores was assessed using Spearman's rank-order correlations analyses. More specifically, correlations were performed between the SF-36v2 component scores (PCS and MCS) and (1) the SCIM-III total score, (2) the SCIM-III subscores (self-care, respiration and sphincter management, mobility and transfers), and (3) each of the SCIM-III 19 single items for the total cohort of patients. Results were reported using the Spearman's coefficient and the corresponding *P* value. As a second step, all analyses were repeated separately for subjects with tetraplegia and paraplegia. All statistical analyses were performed using the IBM SPSS Statistics 21 software (Chicago, IL). The level of statistical significance was set at an α level of 0.05. Statistically significant correlation coefficients were considered clinically large if greater than 0.5, moderate if greater than 0.3, and small if greater than 0.1, according to suggestions from Cohen et al.[19,20]

RESULTS

Patients' sociodemographic and clinical characteristics are shown in Table 1. Sixty-five percent of the cohort sustained tetraplegia. Results from the correlation studies between SCIM-III subscores and total score as well as the QoL (SF-36v2 component scores) are shown in Table 3. Results from the correlations between and individual SCIM-III items and SF-36v2 component scores are shown in Table 4.

Considering the complete cohort, significant moderate positive correlations were found between PCS and mobility, total SCIM-III score, and self-care. Although the mobility subscore was most importantly correlated to PCS, the correlation with respiration/sphincter management subscore was significant but small. The MCS was negatively correlated with SCIM-III subscores and total score, but correlation coefficients were small although significant (Table 3).

TABLE 3. Spearman correlation coefficients between categories of the SCIM-III and the SF-36v2 PCS and MCS scores for patients with a TSCI

		PCS	MCS
	SCIM-III Category	**ρ Coefficient**	**ρ Coefficient**
Total cohort	Self-care	0.421[a]	−0.114
	Respiration and sphincter management	0.370[a]	−0.118
	Mobility	0.516[a]	−0.147[b]
	Total	0.482[a]	−0.124
Tetraplegia	Self-care	0.519[a]	−0.132
	Respiration and sphincter management	0.444[a]	−0.202[b]
	Mobility	0.556[a]	−0.149
	Total	0.541[a]	−0.154
Paraplegia	Self-care	0.225	−0.052
	Respiration and sphincter management	0.069	0.138
	Mobility	0.397[a]	−0.161
	Total	0.236	0.041

[a] $P < 0.01$.
[b] $P < 0.05$.

TABLE 4. Spearman correlation coefficients between individual items of the SCIM-III and the SF-36v2 PCS and MCS scores for the total cohort of patients with a TSCI, and separated based on the presence of tetraplegia or paraplegia

		All Patients		Tetraplegic		Paraplegic	
		PCS	MCS	PCS	MCS	PCS	MCS
	SCIM-III Item	r_s	r_s	r_s	r_s	r_s	r_s
Self-care	1	0.359[a]	−0.173[b]	0.489[a]	−0.200[b]	0.040	−0.065
	2a	0.388[a]	−0.143[b]	0.479[a]	−0.159	0.205	−0.085
	2b	0.425[a]	−0.106	0.468[a]	−0.103	0.369[a]	−0.123
	3a	0.319[a]	−0.101	0.472[a]	−0.139	−0.181	0.206
	3b	0.327[a]	−0.110	0.475[a]	−0.160	−0.077	0.072
	4	0.281[a]	−0.080	0.388[a]	−0.058	−0.022	−0.106
Respiration and sphincter management	5	0.103	−0.123	0.119	−0.153	—	—
	6	0.326[a]	−0.121	0.404[a]	−0.205[b]	0.063	0.084
	7	0.296[a]	−0.087	0.400[a]	−0.211[b]	0.045	0.137
	8	0.400[a]	−0.160[b]	0.479[a]	−0.209[b]	0.170	−0.032
Mobility	9	0.307[a]	−0.117	0.356[a]	−0.095	0.273[b]	−0.172
	10	0.331[a]	−0.158[b]	0.406[a]	−0.134	0.159	−0.243[b]
	11	0.334[a]	−0.106	0.400[a]	−0.106	0.181	−0.086
	12	**0.502**[a]	−0.170[b]	**0.555**[a]	−0.230[a]	0.344[a]	−0.071
	13	0.484[a]	−0.134	**0.513**[a]	−0.146	0.361[a]	−0.107
	14	**0.533**[a]	−0.165[b]	**0.568**[a]	−0.160	0.405[a]	−0.159
	15	0.476[a]	−0.106	**0.530**[a]	−0.141	0.337[a]	−0.066
	16	0.356[a]	−0.203[a]	0.435[a]	−0.204[b]	0.169	−0.177
	17	0.355[a]	−0.178[b]	0.464[a]	−0.209[b]	0.102	−0.089

The important correlation coefficient are highlighted in bold.

[a] $P < 0.01$.

[b] $P < 0.05$.

Similar trends were observed between SCIM-III scores (total and subscores) and PCS and MCS when analyzing separately tetraplegic patients (Tables 3, 4). Moreover, all correlation coefficients increased while reaching a large correlation between mobility and PCS. However, there was no significant correlation for paraplegic patients between the self-care and respiratory/sphincter management subscores and PCS, whereas only a significant moderate correlation was found between the mobility subscore and PCS.

When correlating individual SCIM-III items with PCS and MCS, all individual items (except item 5 - respiration) were significantly correlated to the PCS in the total cohort, particularly for items 14-12-13 (mobility outdoors-indoors-moderate distances). Large correlation coefficients were obtained with respect to items 14 (mobility outdoors) and 12 (mobility indoors), whereas other significant correlations were moderate (Table 3). In accordance with correlations found between SCIM-III subscores and PCS, the strength of correlation was largest for items related to mobility, followed by items for self-care and by items for respiration and sphincter management. In general, individual SCIM-III items were not correlated with MCS, although small significant correlation coefficients were observed inconsistently (Table 4).

In the tetraplegic group, mobility indoors (item 12), mobility for moderate distances (item 13), mobility outdoors (item 14), and stair management (item 15) were largely correlated with PCS. All other items (except item 5) showed moderate correlation coefficients, but these coefficients were closer to the cut-off value used to detect large correlations,[19,20] when compared with the results for the total cohort. Similarly to the total cohort, correlation coefficients were largest for items related to mobility, followed by items for self-care and respiration/sphincter management for individuals with tetraplegia.

In the paraplegic subgroup, moderate significant correlations with PCS were found for lower body bathing (item 2B), mobility indoors (item 12), mobility for moderate distances (item 13), mobility outdoors (item 14), and stair management (item 15).

DISCUSSION

This is the first study that evaluates the relationship between specific functional abilities and HRQoL for patients with TSCI. Although some studies investigated the global functional status with validated tools and their relationship with QoL, this study is unique because it separates items of the widely used and validated SCIM-III questionnaire to objectively assess which specific functional ability is primarily correlated to QoL. It establishes an order of significance for different abilities according to patient's perceived QoL measured in a precise point in time in the chronic phase of SCI.

Our results on the association between total SCIM-III score and HRQoL are in line with previous studies. In particular, Tramonti et al.[14] found a large significant correlation ($r = 0.72$, $P < 0.001$) between the total SCIM-III score and the physical functioning subscale of the SF-36v2 for 40 patients with SCI injury, 45% of which were caused by trauma. Based

on a larger cohort including 195 patients with both paraplegic and tetraplegic patients, we further confirmed the findings of Tramonti et al.[14] Accordingly, in a post hoc subanalysis, we found that the total SCIM-III score correlated strongly with physical functioning ($\rho = 0.741$, $P < 0.001$ in all patients, $\rho = 0.780$, $P < 0.001$ in tetraplegic patients, and $\rho = 0.618$, $P < 0.001$ in paraplegic patients). Other reports also show findings in accordance with the trend observed in our study. Of the 357 patients surveyed, Mittman et al.[1] studied a cohort of patients with an SCI for which more than 75% occurred secondary to a traumatic event. They also found a robust relationship between the SCIM-III total score and an HRQoL score. However, in aiming to compare the SCI population with other disability groups, they used the Health Utility Index-Mark III score that has not been validated in adults with SCI.[1] The other authors that investigated the relationship between function status and QoL relied on functional scores that are not SCI specific.[8,10–13] Even though the QoL measures vary from one study to another, their results all show positive association between functional independence and QoL as well. The fact that this finding recurs, regardless of method and compared scores, serves to support our results and adds to the relevance the deeper analysis of the importance of functional status presented in this study.

Our study highlights the relative order of importance for subscores and individual items with respect to the HRQoL. The PCS was mainly correlated with the mobility subscore, followed by the self-care subscore and by the respiration and sphincter management subscore. The trend was observed particularly in tetraplegic patients. Mobility was the only subscore that correlated with PCS in paraplegic patients, which is consistent with the conclusions of Simpson et al.[5] regarding the high priority for walking in this population. They nevertheless suggested that arm and hand function was a priority considered more important than mobility for recovery in tetraplegic patients. However, in the two largest survey studies they included in their analysis, there was only one mobility-related question.[21,22] In contrast, the SCIM-III questionnaire evaluates nine different items related to mobility (Table 4). This discrepancy could account for the differing order of importance between our objective evaluation of functional abilities and assessments from previous subjective survey studies.

It is well recognized that mobility is an important contributor to QoL in SCI population.[23] Dependence on others for mobility is known to greatly affect QoL in the chronic SCI setting.[24] In our study for both tetraplegic and paraplegic patients, mobility on even surface (items 12, 13, 14) was more strongly correlated with PCS than items related to transfers (items 16, 17). This result is in agreement with a previous study suggesting that walking was a top priority, followed by standing, transferring, and stair climbing, regardless of level of injury.[23] Therefore, our study suggests that higher mobility is better correlated to QoL than higher arm/hand function for both tetraplegic and paraplegic subjects.

The self-care subscore may be an important endpoint after a cervical TSCI because activities related to self-care are highly dependent on upper limb function and hand dexterity.[5] It is therefore not surprising that a large correlation coefficient was observed between the self-care subscore and PCS. Similarly, the correlations between individual items for self-care and PCS almost reached 0.5.

As suggested by Simpson et al.,[5] bowel and bladder management is usually considered as an important priority, although less important than motor function. However, no correlation was found between respiration/sphincter management subscore nor individual items and QoL among paraplegic patients in our cohort. Potential explanations could reside in the small variability in paraplegic patients for items 6-7-8 that precludes adequate correlation analysis. In the subgroup of paraplegic patients, 82% scored ≥9/15 on item 6, 59% scored ≥8/10 on item 7, and 94% scored ≥8/10 on item 8. Sphincter dysfunction associated with TSCI remains very disturbing for patients, because it may seriously impact the self-esteem and social activities.[25] Some studies have also reported cultural variation on the perception of sphincter dysfunction on the QoL, which is also important to consider.[26–28]

Respiratory dysfunction may greatly vary according to the severity and the level of the spinal cord injury. In most severe cases, respiratory insufficiency may lead to permanent mechanical ventilation support.[29] It is thus not surprising that respiratory dysfunction was previously shown to impact the QoL of SCI patients.[30] Accordingly, Charlifue et al.[31] reported better health perception and improved QoL in nonmechanically ventilated patients versus those requiring mechanical ventilation. A recent study by Postma et al.[30] showed that more severely impaired respiratory function was associated with lower HRQoL, taking into account functional vital capacity, cough strength, dyspnea, and pulmonary infection burden. On the opposite, the SCIM-III evaluates independence in respiration regardless of such quantitative pulmonary function parameters. No correlation was found between the respiration item and the SF-36v2 summary scores in our cohort. This could be explained by the fact that the great majority of the cohort was completely independent for respiration management, again resulting in a small variability in our cohort, which limits the use of correlation studies.

What could be seen as counter-intuitive is the absence of significant correlations between the SCIM and MCS, reflecting the absence of heightened mental health in patients with better function status. This is in agreement with Tramonti et al.[14] who did not find any correlation between the SCIM-III total score and mental health assessed from the SF-36v2. It is also in agreement with previous studies showing the absence of a relationship between QoL mental health summary scores and neurological function.[2,32,33] These findings suggest that mental health after a TSCI strongly depends on other factors that were not considered in the current study. For example, it is known that many psychological factors influence QoL such as depression,[34] pain,[35] locus of control, sense of coherence, hope, purpose in life, or feelings of self-worth.[36] Therefore, in the future, thorough study of the impact of function on MCS should ideally include these factors as potential co-variables.

The current study showed that it is of paramount importance to analyze tetraplegic and paraplegic patients distinctly when evaluating impact of function on QoL, considering the magnitude of difference between the strength of correlation with SCIM subscores. Different priorities for patients lead to distinct goals in the rehabilitation effort. For tetraplegics, mobility indoors, mobility for moderate distances 10–100 meters, and stair management are major items helping determine potential for discharge at home, and mobility outdoors is decisive for patient's ability to participate in the community. In addition,

feeding and ability to dress, as well as toilet use, are significant factors in planning for degree of assistance needed at home or long-term care facilities after discharge from rehabilitation center. In paraplegic patients, considering that the disability primarily involves lower limbs, it was expected to find stronger correlation with bathing lower body than with other self-care items, because such task requires a significant contribution from the lower limbs.

LIMITATIONS

Our main limitation is related to the objective questionnaires that were used to assess function and QoL in this study. Although our global objective was to determine specific functional abilities that are related to the QoL, we recognize that our results are limited to the outcome measures that were used (SF-36v2 and SCIM). However, the SCIM-III has proven to be reliable and valid in the TSCI patient population[16,37] and useful for postinjury rehabilitation programs.[38] Its simplicity for patients, use of validated items, and ability to establish objective information makes it an ideal functional outcome questionnaire.

In line with the goal of objectively establishing priorities in the TSCI population, we chose to use the SF-36 questionnaire because it has been widely used and therefore translated for more than 60 countries, which allows for comparison with many other populations.[18] Finally, a study including a higher number of subjects may improve the correlation precision on items exhibiting weak score variability. Future studies aiming to further assess the relationship between function and QoL should base their analyses on the impact of specific known predictors of function, such as functional status at discharge from acute care, acute care length of stay, presence of a specialized multidisciplinary functional rehabilitation process, prevention of medical complications and intensity, and patient participation level in functional rehabilitation therapies.

CONCLUSIONS

This is the first study to objectively evaluate the relative importance of specific functional abilities in patients with TSCI. Independence in mobility items is the most important functional ability related to improved PCS, followed by self-care items and sphincter management. Functional abilities assessed from the SCIM-III were not significantly related to MCS.

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