



Original research

# Association Between SCIM III Total Scores and Individual Item Scores to Predict Independence With ADLs in Persons With Spinal Cord Injury



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## KEYWORDS

Paraplegia;  
Probability;  
Prognosis;  
Rehabilitation;  
Tetraplegia

**Abstract** *Objective:* To clarify the activities of daily living (ADL) structure of persons with spinal cord injury (SCI) by analyzing the associations between the Spinal Cord Independence Measure III (SCIM III) total score and individual SCIM III item scores.

*Design:* A retrospective survey.

*Setting:* A national hospital with 2 SCI units in Japan.

*Participants:* Inpatients (N=81) within 60 days of SCI onset were included (men, 84%). The mean age was 62 years. Of these, 63 persons had incomplete SCI (47 persons had tetraplegia).

*Interventions:* Not applicable.

*Main Outcome Measure:* SCIM III was used to assess the ADL independence level on a monthly basis during hospitalization. SCIM III data were analyzed with ordinal logistic analyses.

*Results:* The analyses revealed that SCIM III total scores accounted for the probabilities of individual SCIM III item scores. Goodness-of-fit of each logistic model by Wald test was significant ( $P < .001$ ,  $R^2_{McFadden} = 0.183-0.598$ ). Some items in the self-care domain showed a shallow (ie, less steep) logistic curve. Regarding the feeding item, a total score of 80 was needed to attain the complete independence level, while patients with a total score  $>10$  attained modified independence level.

*List of abbreviations:* ADL, activities of daily living; AIS, American Spinal Injury Association Impairment Scale; SCI, spinal cord injury; SCIM III, Spinal Cord Independence Measure version III.

Supported by a JSPS Grant-in-Aid for Scientific Research C (grant no. 15K01407 to Osamu Uemura).

Disclosures: none.

Presented in part to the Japanese Association of Rehabilitation Medicine, June 7, 2014, Aichi, Japan.

Cite this article as: Arch Rehabil Res Clin Transl. 2019;1:100029.

<https://doi.org/10.1016/j.arrct.2019.100029>

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**Conclusions:** The SCIM III total score can provide information on the probability and degree of difficulty of attaining independence for each item. Therefore, the present total SCIM III scores could be the indication for ADL attainment. In addition, the higher total SCIM III score and the probability of individual items score are useful for planning efficient rehabilitative approaches, considering the degree of difficulty of attaining independence for each item. Moreover, our results show good generalizability across patients with complete and incomplete SCI.

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One of the main targets of rehabilitation medicine is optimizing the quality of life for persons with debilitating medical conditions. The first step in an efficient rehabilitative intervention is assessing disability. The FIM is a general measure because it covers most disabilities in any medical condition; however, this measure is insufficient for the detailed evaluation of specific medical conditions such as spinal cord injury (SCI).<sup>1,2</sup> The Spinal Cord Independence Measure version III (SCIM III) was developed to evaluate disability and functional changes in persons with SCI. The SCIM III contains 19 items in 3 major domains: 6 for self-care (score range, 0-20), 4 for respiration and sphincter management (score range, 0-40), and 9 for mobility (score range, 0-40). The total score (maximum 100 points) is computed as the sum of weighted subscales in each item. Because of this detailed and weighted scoring system, the SCIM III is more sensitive to change than the FIM.<sup>3</sup> A previous study validated the psychometric properties of the SCIM III and demonstrated its concurrent validity with the FIM.<sup>4</sup> Accordingly, the SCIM III is validated for use in SCI rehabilitation.

Based on accumulated knowledge, physicians can now roughly predict the outcomes of persons with complete SCI. Marino et al<sup>5</sup> reported that 85% of persons classified as ASIA (American Spinal Injury Association) Impairment Scale (AIS) A at admission had no change in AIS at 1 year postinjury. In contrast, persons with AIS B and C showed progressive recovery, with only 19% and 25% showing no change in AIS at 1 year postinjury, respectively.<sup>5</sup> Despite the absence of change in AIS grade, 30% of persons with tetraplegia and 60% of those with paraplegia experienced motor recovery below the level of injury. This motor recovery contributed to SCIM II score changes in persons with complete SCI.<sup>6</sup> Regardless of the completeness of SCI, persons with paraplegia showed favorable motor score and SCIM II score improvements compared to those with tetraplegia.<sup>6-9</sup> In another study evaluating changes in SCIM II scores at 5 months after injury, persons with incomplete SCI showed a more dispersed score distribution than those with complete SCI.<sup>10</sup> These data suggest that the prediction of functional outcome is more complicated in incomplete SCI than in complete SCI.

Koyama et al<sup>11</sup> found that the probability to attain independence in each motor FIM item can be estimated by the total motor FIM scores in the stroke population using ordinal logistic analyses. This result had utility for planning rehabilitative interventions, eg, identifying ADL item targets by reviewing the total motor FIM scores. No study to

date has similarly investigated associations between SCIM III total scores and individual item scores in persons with SCI. Therefore, the purpose of this study was to evaluate associations between the SCIM III total score and individual SCIM III item scores to examine the ADL structure of inpatients with complete and incomplete SCI.

## Methods

This was a retrospective, single-center study performed at Murayama Medical Center, Tokyo, Japan. We extracted medical records of inpatients with SCI who were admitted to the hospital for rehabilitation and discharged between May 2013 and September 2015. Inclusion criteria were as follows: no past history of SCI; admitted to the rehabilitation ward within 60 days of onset; and no complications that restricted rehabilitation programs such as pulmonary embolism, visual impairment, and severe cognitive disorder. We gathered clinical data from medical records including age, sex, SCI onset, etiology, length of hospitalization, AIS grade, and SCIM III scores. Each inpatient was evaluated monthly with the SCIM III by trained and experienced nurses. SCIM III scores were collected for up to 1 year postadmission for those who were hospitalized for >1 year. We used final SCIM III scores for inpatients discharged <1 year postadmission. When both total and individual item SCIM III scores were identical in consecutive months, we only used 1 score set and omitted the other. We excluded inpatients with incomplete records. The study was approved by the local institutional review board.

Pairwise comparisons were performed between SCIM III scores and age and sex, and length of hospitalization using the *t* test and Mann-Whitney *U* test, respectively. Pearson product-moment correlation coefficient was used for correlation analysis between age and SCIM III on admission. Ordinal logistic analysis was used to determine correlations between SCIM III total scores and individual SCIM III item scores as previously described.<sup>3</sup> The total score was defined as an explanatory variable, and individual item scores were defined as dependent variables. In this study, we tested each model by Wald test and used the McFadden  $R^2$  supportively to assess goodness-of-fit of the logistic analysis.<sup>11</sup> All statistical analyses were performed using IBM SPSS version 23.0.<sup>a</sup> A *P* value < .05 was considered statistically significant. The respiration domain was excluded from the evaluation because all participants had independent level of respiration.

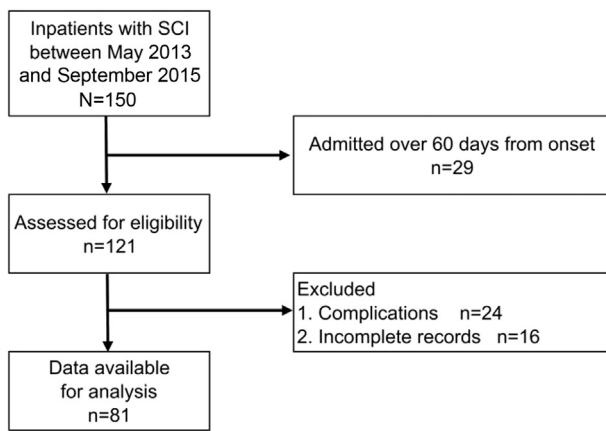


Fig 1 Inpatient recruitment flow diagram.

Results

After reviewing all medical information, 81 inpatients were included (fig 1). The characteristics of the study population are presented in table 1. The mean age was 62±17 years. Fifty-two participants were persons with tetraplegia, and the remainder 29 were persons with paraplegia. AIS grade was A in 18, B in 1, C in 16, and D in 46 persons. Thirty-five participants were persons with tetraplegia and AIS D severity. Lesion etiology was traumatic in 50 persons (62%). The mean age and mean SCIM III score on admission were significantly different between the tetraplegia and paraplegia groups (P=.012 and .002, respectively). The total SCIM III score was significantly higher in nontraumatic SCI than in traumatic SCI (P=.003). Pearson product-moment correlation coefficient showed that age was not associated with the SCIM III on admission (r= -0.105, P=.349).

Figure 2 and table 2 display associations between the independence level of individual SCIM III items and the SCIM III total score. In fig 2, the left vertical axis shows logistic probability, horizontal axis shows SCIM III total scores, and right vertical axis is divided according to the proportion of each estimated SCIM III value. The P values of Wald test for significance of parameters in each model were <.001, and McFadden R<sup>2</sup> indicated consistency ranging from 0.183 to 0.598. Logistic curves were steep for the mobility domain and less steep for the self-care domain. We performed subgroup analyses for complete and incomplete SCI (data not shown). The shapes of logistic curves for incomplete SCI were similar to those presented in fig 2. In contrast, complete SCI had a narrower total score distribution and steeper logistic curves. Distributions of individual SCIM III item scores were overlapping between the incomplete and complete SCI groups.

Figure 3 showed the SCIM III total score at which 50% of the participants were at the modified independence level, ie, self-care items, 2; bladder, 9; bowel, 8; use of toilet, 4; mobility in bed, 6; transfers, 2; mobilities, 2; and stairs, 2, or better. Feeding and mobility (indoor or moderate distance) were relatively easy tasks; a total SCIM III score of 30 represented a 50% chance to achieve modified independence. In contrast, stair management and transfers (ground-wheelchair, wheelchair-car) were rather difficult to achieve; these items required a total SCIM III score of 70 to have a 50% chance of independence. We divided the participants into 2 groups, paraplegia and tetraplegia, and performed the same ordinal logistic analysis in each group. The paraplegia group achieved some self-care items, such as feeding, dressing upper, and grooming at a lower SCIM III total score. In contrast, the tetraplegia group achieved stair management at a lower score.

Table 1 Patient characteristics (N=81)

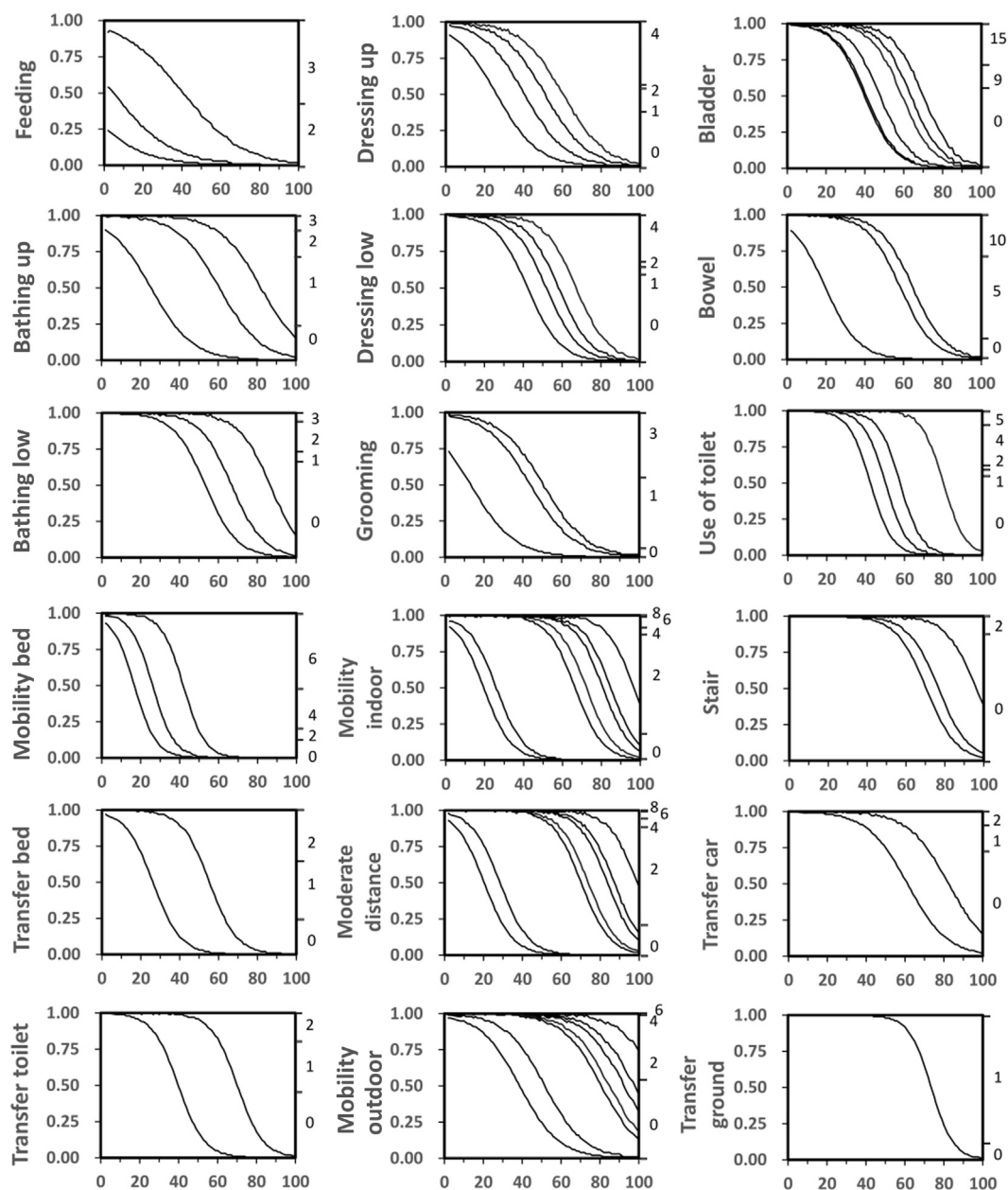
Characteristics	N	Age (y)	Days From Onset (d)	Length of Hospitalization (d)	SCIM III on Admission	SCIM III on Discharge
Total	81	62 (20-91)	35 (11-60)	183 (23-489)	33 (2-92)	60 (10-100)
Traumatic SCI	50	61 (20-91)	33 (11-60)	183 (45-489)	27 (2-92)*	58 (10-100)
Nontraumatic SCI	31	63 (23-87)	41 (14-55)	191 (23-482)	43 (12-91)*	63 (23-92)
Tetraplegia	52	65 (22-91)†	34 (11-60)	172 (45-489)	27 (2-92)‡	55 (10-100)
AIS						
A	5	53 (22-72)	30 (14-39)	358 (273-432)	14 (12-16)	36 (24-44)
B	1	23	35	482	12	#
C	11	68 (35-91)	34 (14-52)	197 (120-489)	14 (2-26)	39 (15-100)
D	35	68 (36-84)	33 (11-60)	159 (45-346)	34 (10-92)	62 (10-97)
Paraplegia	29	55 (20-87)†	41 (15-56)	235 (23-442)	33 (14-91)‡	59 (28-92)
AIS						
A	13	50 (20-74)	38 (15-56)	268 (144-442)	29 (14-50)	56 (28-74)
B	0					
C	5	52 (25-87)	41 (29-50)	148 (105-412)	44 (24-72)	75 (64-88)
D	11	59 (38-83)	41 (18-55)	183 (23-364)	54 (26-91)	77 (57-92)

NOTE. Age and SCIM score are presented as the mean (range). Days data are presented as the median (range).

\* P=.003.

† P=.012.

‡ P=.002.



**Fig 2** Logistic probability plots of relations between SCIM III total scores and independence level of individual SCIM III items ( $n=391$ ). The left vertical axis shows the logistic probability, and the horizontal axis shows SCIM III total scores. The first curve shows the probability attributed to level 0. The next higher curve shows the probability attributed to next independence level. The right vertical axis is divided according to the proportion of each estimated SCIM III value.

## Discussion

We analyzed the association between SCIM III total scores and individual SCIM III item scores using ordinal logistic analyses to show the expected ADL level 1 year after SCI onset and provided a step-by-step index for efficient rehabilitation planning. For example, when the total SCIM III score is 40, 50% of persons with SCI would attain modified independence in dressing upper item. When a patient with a total score of 40 needs assistance in this item, the first target should be this. In contrast, if one is independent in

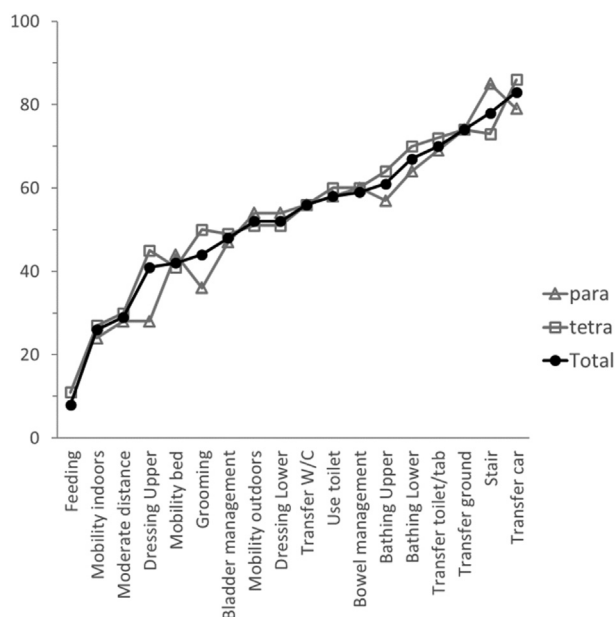
this item, the next target should be mobility bed. The goal of ADL in complete SCI is determined based on the level of neurologic impairment.<sup>12</sup> In contrast, our study evaluated both complete and incomplete SCI, regardless of neurologic status. Because incomplete SCI is more common than complete SCI<sup>13</sup> and given the observation of only minor differences between complete and incomplete SCI in subgroup analysis, we believe that our data are useful for guiding SCI treatment in daily practice.

Because individual SCIM III items are components of the total SCIM III score, a correlation is inevitable. In

**Table 2** Parameter estimates for ordinal logistic equations

Parameter	$\beta$	$\alpha$										$R^2$				
		Ordinal logistics (independence level of SCIM item)														
		0	1	2	3											
Feeding	0.066	-1.007 (-1.637 to 0.378)	0.303 (-0.193 to 0.800)	2.675 (2.115-3.235)												0.183
Bathing up	0.094	2.379 (1.872-2.885)	5.676 (4.881-6.471)	7.697 (6.733-8.661)												0.299
Bathing low	0.123	6.518 (5.503-7.534)	8.189 (7.002-9.375)	10.605 (9.180-12.03)												0.412
Grooming	0.089	1.177 (0.677-1.677)	3.902 (3.262-4.542)	4.499 (3.814-5.183)												0.270
Dressing up	0.094	2.450 (1.939-2.961)	3.805 (3.216-4.393)	4.792 (4.125-5.460)	5.664 (4.924-6.404)											0.254
Dressing low	0.120	5.065 (4.301-5.829)	6.212 (5.341-7.082)	6.978 (6.033-7.923)	8.071 (7.026-9.116)											0.359
Bladder	0.127	5.070 (4.328-5.813)	5.201 (4.449-5.954)	6.094 (5.263-6.926)	7.543 (6.561-8.525)	8.115 (7.081-9.149)	8.992 (7.820-10.02)									0.343
Bowel	0.117	2.307 (1.753-2.862)	6.822 (5.809-7.834)	7.573 (6.499-8.647)												0.375
Use of toilet	0.180	7.671 (6.575-8.766)	9.055 (7.812-10.30)	10.412 (9.014-11.81)	14.447 (12.58-16.31)											0.506
Mobility bed	0.180	3.008 (2.280-3.737)	4.697 (3.873-5.520)	7.525 (6.389-8.660)												0.473
Transfer bed	0.141	3.700 (3.015-4.386)	7.810 (6.640-8.979)													0.482
Transfer toilet	0.151	6.005 (5.039-6.970)	10.57 (8.972-12.17)													0.523
Mobility indoor	0.142	2.772 (2.173-3.372)	3.691 (3.062-4.319)	9.466 (8.122-10.81)	10.282 (8.874- 11.69)	11.49 (9.977-13.00)	12.059 (10.50-13.62)	13.746 (12.00-15.49)								0.353
Mobility moderate	0.138	2.798 (2.195-3.401)	3.913 (3.266-4.560)	9.667 (8.292-11.04)	10.17 (8.757-11.58)	11.522 (9.992-13.05)	12.00 (10.43-13.57)	13.624 (11.87-15.38)								0.347
Mobility outdoor	0.099	3.849 (3.235-4.462)	5.140 (4.425-5.856)	8.031 (7.031-9.031)	8.450 (7.418-9.483)	9.212 (8.114-10.31)	9.733 (8.581-10.89)	11.034 (9.654-12.41)								0.277
Stair	0.129	9.086 (7.249-10.92)	9.899 (7.982-11.82)	12.404 (10.19-14.62)												0.392
Transfer car	0.097	5.948 (4.921-6.976)	8.008 (6.876-9.229)													0.353
Transfer ground	0.175	12.906 (9.468-16.34)														0.598





**Fig 3** SCIM III total scores for attaining a 50% probability of at least the modified independence level for individual SCIM III items. Data are derived from the logistic analysis shown in [fig 1](#). Abbreviations: transfer W/C, bed-wheelchair transfer; para, paraplegia; tetra, tetraplegia.

disagreement with this argument, Koyama et al<sup>11</sup> performed both an initial correlation analysis on the total score and target item score and a second analysis using a total score that excluded the targeted individual item and found similar correlations in both analyses. We performed the same analyses and obtained similar results (data not shown). Therefore, we suggest that the SCIM III total score is useful as an indicator of individual SCIM III item scores.

The logistic curve exhibited a unique pattern for each SCIM III item. A leftward shift of the logistic curve indicated that the ADL item was relatively easy to perform, and spaces between neighboring logistic curves within each item represented relative difficulties of attaining the next level within each item. Feeding and grooming items were the easiest ADL items, such that even persons with low SCIM III total scores achieved at least the modified independence level; however, larger improvements were necessary to achieve complete independence. This finding is consistent with previous reports in stroke.<sup>11,14</sup> Our observation may be related to the fact that feeding and grooming activities can be trained without leaving the bed, permitting early intervention. In contrast, logistic curves for bathing the lower body, use of toilet, transfers (ground-wheelchair, wheelchair-car), and stair management were shifted to the right, indicating that independence would only be probable in persons with high SCIM III total scores. Among these items, stair management and transfers (ground-wheelchair and wheelchair-car) were the most difficult: persons with a SCIM III total score of at least 50 were able to achieve independence for these items. As our analysis demonstrated, a simple comparison of the shapes of logistic curves can permit clinicians to easily recognize the relative difficulties

between and/or within individual ADL items. A previous study used a Rasch analysis to assess the difficulty of individual SCIM III items.<sup>15</sup> This analysis evaluated persons with SCI from 6 countries (35.0% AIS A, 13.9% AIS B, 21.6% AIS C, 28.0% AIS D; 188 persons with tetraplegia and 237 with paraplegia) with a mean age of  $46.93 \pm 18.17$  years; although the cohort was younger than ours, it showed very similar patterns of difficulty for the modified independence level for almost all SCIM III items except for bathing, which had higher difficulty. Tsuji et al<sup>14</sup> also reported the difficulty of bathing in persons with stroke in Japan than in those in the United States. This may reflect cultural differences in bathing worldwide. Catz et al<sup>15</sup> reported differences in the difficulty of other ADL items among 6 countries; accordingly, attention should be paid to the influence of cultural differences on ADL difficulty.

In this study, the shapes of logistic curves were steep for mobility in bed, use of toilet, and transfers (bed-wheelchair, wheelchair-toilet-tub, ground-wheelchair). Steepness of the logistic curve indicates that tiny changes in the SCIM III total score affected the probability of attaining the next ADL level. Less steep curves for grooming and feeding suggested that even persons with high total SCIM III scores were unlikely to attain complete independence level. Because grooming and feeding are relatively easy to achieve at the modified independence levels, a less steep curve seems illogical. The reason for this observation may be related to participant characteristics. This study included a high percentage (43%) of persons with tetraplegia of AIS D. They have difficulties in skilled movement like self-care items even though they show high performance in other ADL domains. Catz et al<sup>15</sup> also described the paradox that low performers had more difficulty with upper limb-related items than mobility items in the Rasch analysis. Moreover, feeding and grooming items showed a low  $R^2$  value in the present study. Therefore, unique participant characteristics may influence the shape of logistic curves for upper limb items. They also reported that differential item functioning was of minor relevance for most items across the lesion level. Our results, however, showed a clear difference in probabilities of independence in some ADL items between paraplegia and tetraplegia. This discrepancy between present and previous studies might be due to participant demographics. Compared to previous studies, our study included a high percentage of individuals with incomplete tetraplegia. Rapid aging in Japanese society influences the demographics of SCI. In the early 1990s, there was a diphasic feature in age distribution.<sup>16</sup> A recent survey revealed that persons older than 60 years accounted for approximately 60% of newly registered SCI.<sup>17</sup> This study also showed that >20% of incomplete SCI occurred in individuals older than 60, suggesting that incomplete SCI is an important disability-associated injury in older adults. Because outcome prediction of incomplete tetraplegia is more difficult, our results could serve as a useful tool for the evaluation of each ADL achievement in addition to the present ADL level. Moreover, according to the United Nations, the number of older persons shows an increasing trend worldwide.<sup>18</sup> It is possible that the SCI demographic change observed in Japan will be common in other countries in the near future. Therefore, our results could be applied not only to Japan but worldwide.

In our study, a difference in the order of achievement between paraplegia and tetraplegia was observed. In the total population, the expected SCIM III total scores to attain modified independence in feeding and mobility (indoors or moderate distance) were approximately 10-30. The expected SCIM III total scores gradually increased according to the relative difficulties of each ADL item. This tendency was observed in both paraplegia and tetraplegia with some exceptions. In the feeding, grooming, dressing upper, and stair items, the achievement levels were different between tetraplegia and paraplegia. One reason may be the difference in the complete SCI ratio between tetraplegia and paraplegia. In our study, the proportions of complete lesions in the paraplegia and tetraplegia groups were approximately 45% and 10%, respectively. Feeding, grooming, and dressing upper can be performed with upper extremity function; these items might not be influenced by trunk function. Thus, it is difficult to attain modified independence level for these items with tetraplegia, but not paraplegia. As mentioned above, in our cohort, approximately 90% of participants with tetraplegia had incomplete injury. Regardless of the types of injury, such as central cord syndrome, incomplete tetraplegia was shown to have a favorable functional outcome in terms of ambulation.<sup>19</sup> With intensive exercises and appropriate braces, persons with complete paraplegia could climb and go down the stairs.<sup>20</sup> Because of energy consumption, costs, and/or living arrangement, however, compliance to brace ambulation in daily life was far from satisfactory.<sup>21</sup> According to the recent report by van Middendorp et al, the chance of individuals with complete paraplegia achieving independent ambulation was quite low, especially for those with older age.<sup>22</sup> The mean age of the participants in this study was relatively old; they had quite a small chance of regaining independent walking. This difference in our cohort might have influenced the difference in the relative difficulty with the stair item between tetraplegia and paraplegia.

There is a body of research centered on the prediction of functional recovery poststroke. Koyama et al<sup>23</sup> used 2 initial timepoint FIM scores to predict functional recovery at arbitrary timepoints using logarithmic model in persons with stroke. Wirth et al<sup>10</sup> showed that SCI is also likely to fit the logarithmic model regardless of the type of injury. Thus, SCI outcomes could be predicted with a simple mathematical function. If we can obtain the total SCIM score at specific timepoints, it would be possible to calculate probabilities of independence for single SCIM III items by the logistic analysis used in the present study. This would ultimately permit a more precise and goal-oriented rehabilitation scheme and is an aim for future studies. Better planning for SCI rehabilitation may reduce the anxiety and socioeconomic burden of both persons with SCI and their families in addition to enhancing their motivation toward rehabilitation.

### Study limitations

Because this study was performed at a single center in Tokyo and since our hospital does not accept patients with severe respiratory impairment, the data used in this study

may be different from those in other regions in Japan and/or in the world. It would be necessary to confirm generalization across the country. The tool usage can be limited by participant characteristics. First, in this study, we excluded inpatients with severe cognitive disorders, while 62% of participants had traumatic SCI. Macciocchi et al reported that 26% of persons with traumatic SCI had concomitant brain injury.<sup>24</sup> Thus, our inclusion criteria might have distorted the demographics. Second, this study was conducted on older participants, whose mean age was 62. Previous studies have shown that the functional outcome of participants who are older at the time of injury is lower than that of younger participants.<sup>25-27</sup> Although the total score in this study tended to be low due to the age, the effects on individual items score are small. Some elderly participants also have comorbidities. In this study, no participant had comorbidities that limit rehabilitative training. Attention must be paid when applying our results to persons with severe comorbidities and physical limitations.

In this study, the *P* values of each model by Wald test, that were  $<.001$ , showed correlation between total SCIM scores, and individual item scores were significant. However, the feeding item showed small  $R^2$  values. The value of McFadden's pseudo  $R^2$  is discordant from  $R^2$  of linear regression because it is defined by likelihood of the model. We showed supportively the result of McFadden  $R^2$  to assess the relative fitness between each model.<sup>28</sup> There might be other factors that contribute to the scores of these items. Further studies are necessary to reveal these factors.

### Conclusions

We employed ordinal logistic analyses to demonstrate that the SCIM III total score is a good predictor of individual SCIM III items scores. Because the present study did not limit the type or severity of SCI included in the analysis, our results regarding this association are generalizable to both complete and incomplete SCI.

### Supplier

a. SPSS version 23.0; IBM Corp.

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