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Factors influencing on functional independence outcomes after hospitalization and rehabilitation in children with spinal cord injury

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Abstract

Objective This study is to investigate the factors that influence functional autonomy outcomes in children who have undergone rehabilitation for spinal cord injury. The aim is to enhance the clinical guidance provided to inpatients at the China Rehabilitation Research Center, Beijing Bo-ai Hospital. Furthermore, the objective is to optimize rehabilitation interventions and establish a scientific basis.

Methods This study employed a retrospective survey method for data collection and analysis. Descriptive analysis, one-way ANOVA analysis, and Multiple logistic regression analysis were utilized to examine the influencing factors associated with the prognosis of functional independence outcomes in children with SCI. The degree of influence of each independent variable on functional independence outcomes was ultimately determined.

Results The total score of SCIM-III at admission was 41.48 ± 4.089, and the total score of SCIM-III at discharge was 50.05 ± 25.028, resulting in a significant difference in the total score of SCIM-III was (8.57 ± 7.000, $p < 0.001$).In one-way ANOVA analysis, Self-care: injury segments, damage plane, ASIA, assistive devices, complications, rehabilitation duration treatment, WISCI-II, UEMS and LEMS, BI, and 6WMD groups were statistically significant ($p < 0.001$). Respiratory and sphincter management: injury segments, ASIA, complications, injury to recovery time interval, rehabilitation duration treatment, WISCI-II, UEMS and LEMS, BI, and 6WMD groups were statistically significant ($p < 0.05$). Move: age, injury segments, damage plane, rehabilitation duration treatment, WISCI-II, UEMS and LEMS groups were statistically significant ($p < 0.05$). SCIM-III total score: age, AISA, assistive devices, injury to recovery time interval, rehabilitation duration treatment were statistically significant ($p < 0.05$). Multiple logistic regression analysis, revealed that the injury to recovery time interval had a negative correlation with the total difference in SCIM-III scale (t = −9.893, $p < 0.001$; 95%CI-12.006~-7.780), while the duration of rehabilitation treatment (t = 4.245, $p < 0.001$, 95%CI 2.636 ~ 5.854) had a positive correlation with different age groups (t = 4.002, $p < 0.001$, 95%CI 2.421 ~ 5.583).

Conclusion The shorter the interval between the time of spinal cord injury and the time of intervention for rehabilitation, the more favorable the functional recovery of the children. Children with SCI who were hospitalized for

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rehabilitation and achieved 3-month daily functional independence scores were more successful. It is recommended that rehabilitation interventions for children with SCI in this institution should be initiated as early as possible and maintained over time. Among the subjects, the prognosis of functional independence was more favorable in the school-age group (6-18y) than in the preschool group (3–6 y).

Keywords Children, Spinal cord injury, Inpatient rehabilitation, Functional independence, Influencing factors

Introduction

A spinal cord injury (SCI) in children is a serious condition that affects their ability to move and walk, and while it is relatively rare in children compared to adults, it can have a significant impact on their quality of life and future development [1, 2]. Previous studies have shown that rehabilitation improves independence and quality of life in children with SCI.However, studies affecting rehabilitation outcomes are less available on pediatric spinal cord injuries, especially in China [3–7].

If we can understand the specific things that affect how well children with SCI can be rehabilitated, we can give better advice to clinicians and rehabilitation therapists. Researchers have already done some research into the rehabilitation of children with SCI, including different types of treatments such as physical therapy and occupational therapy [8]. But not many studies have looked at the specific things that affect how well children can do day-to-day activities after their rehabilitation, especially using the Spinal Cord Independence Measure (SCIM-III) to assess tool.

The present study aims to address this issue by investigating the factors that influence the level of functionality (SCIM-III) of children with SCI following hospitalization and rehabilitation treatment. The objective is to provide clinical guidance for inpatient rehabilitation at the China Rehabilitation Research Center, Beijing Bo-ai Hospital. By identifying the key factors that affect the functionality of children, this study seeks to improve rehabilitation treatment and establish a scientific basis for future practice.

Materials and methods

General information

The study population consisted of pediatric SCI patients who were hospitalized at Beijing Bo-ai Hospital from January 2017 to December 2021 and completed rehabilitation treatment in the Department of Pediatric Physiotherapy. Patients were selected for the study if they met the inclusion criteria. This study was reviewed by the China Rehabilitation Research Center's Ethics Committee (No. 2024IIT--61).

Inclusion criteria: ① Age of injury ≤ 18 years old; ② Diagnosis: SCI, in accordance with international standards or diagnostic criteria of professional organizations, such as the diagnostic, criteria of the National Spinal Cord Injury Association; ③ First time to receive the rehabilitation treatment of the pediatric physical therapy department of the hospital. Exclusion criteria: ① Age of injury > 18 years old; ② Suffering from diagnosis of other diseases, such as craniocerebral injury, deep vein thrombosis, etc; ③ Lack of necessary clinical information or data, such as diagnostic evidence, records of rehabilitation therapy.

Data extraction based on the ICF framework

Body structure

Include age (age at the time of injury), sex, cause of injury, injury segments,damage plane,injury to recovery time interval,rehabilitation duration, complications (neurogenic bladder, urinary tract infections, scoliosis, osteoporosis, etc.), assistive devices (wheelchairs, standing frames, girdles, ankle-foot orthoses (AFOs), knee-ankle-foot orthoses (KAFOs), hip-knee-ankle-foot orthoses (HKAFOs), walking aids, etc.).

Physical functions

Include American Spinal Injury Association (AISA) classification of disability [9], Upper and lower extremity muscle function score (UEMS and LEMS) [10], Walking index for spinal cord injury II (WISCI-II) [11], Barthel index(BI) [12], 6-minute walking distance(6MWD) [13].

Activities and participation

The Spinal Cord Independence Measure III (SCIM-III) was utilized in this study. The scale is comprised of three primary sections, namely self-care, respiratory and sphincter control, and move, with a total of 17 items. The results are scored on a scale of 0 to 100. The self-care section encompasses eating, take a bath, dressing and undressing, and embellished. The respiratory and sphincter management section includes breath, bladder, bowel. The move section is divided into two parts: bed movement and bed-chair conversion, and indoor and outdoor move [14].

Rehabilitation treatment

The hospital's post-admission physiotherapy programme for different ASIA classifications is as follows (Note: Physiotherapy needs to be dynamically adjusted according to the patient's specific condition and the progress of rehabilitation in order to achieve the best therapeutic effect.). Rehabilitation time: 1 time per day, 30–60 min, at least 5 days per week. See Table 1.

Table 1 Physiotherapy protocols after admission for different ASIA classifications

ASIA	Rehabilitation potential	Rehabilitation Focus	Physiotherapy measures	
			acute phase	chronic phase
A	Small	Respiratory Bladder Position	Wearing a brace Breathing and expectoration training Intermittent catheterization Positioning of good limbs Turning regularly Upper limb residual muscle strength training Passive joint movement training	Upper Extremity Residual Muscle Strength and Core Muscle Training Position Transition Training Mobility training Seated Balance Training Joint passive movement training
B	Moderate	Motor function Sensory	Wearing a brace Positioning of good limbs Sensory stimulation training Active joint assisted mobility training	Gradual increase of active movement training Position change training Balance training
C	Large	Residual muscle strength Balance and co-ordination	Wearing a brace Resistance Training Balance and co-ordination training	Muscle Strength Training Position change training Assisted walking training
D	Large	Targeted strength Motor co-ordination	Wearing a brace Resistance Training Balance & Coordination Gait Training	Position Transition Training Gait Training Walking function step-by-step training
E	Normal	Maintenance of motor function Health Education	Daily fitness exercise, sports activities Rehabilitation knowledge dissemination, health guidance etc.	

Functional independence outcomes

In this study, functional independence outcomes were evaluated at the initial stage using the SCIM-III scale.

Baseline: This refers to the preliminary evaluation conducted at the time of patient admission for their initial rehabilitation session. This evaluation comprises a self-care score(0-20point), a respiratory and sphincter management score(0-40point), a move score(0-40point), and a total score.

Recovery: This refers to the second assessment when the patient is discharged from hospital at the conclusion of the rehabilitation treatment. Rehabilitation is measured by comparing the admission score and the discharge score, and includes four parts: the difference in self-care score, the difference in respiratory and sphincter management score, the difference in move score and the difference in total score. Due to the minimal scores in the table for the self-car score difference, Respiratory and Sphincter Management Score difference, and Mobility Score difference. Outcomes 2 was categorised as (change and no change).

Research methodology

This study employed a retrospective survey to conduct a descriptive analysis of fundamental clinical characteristics, rehabilitation treatment, and functional independence outcomes. One-way ANOVA and Multiple logistic regression analysis were employed to ascertain the factors that contribute to the prognostic discrepancy in functional independence outcomes.

Statistical analysis

The SPSS 26.0 software was used for statistical analysis. In descriptive analysis, qualitative data were expressed as frequency/percentage (n/%), and quantitative data were expressed as mean ± standard deviation. One-way analysis of variance, if both the independent and dependent variables were categorical data, a one-way ANOVA was used. If the independent variable was categorical and the dependent variable was quantitative, bivariate correlation analysis (Pearson/Kendall) was used. The screened single factors were analyzed by multiple logistic regression analysis, and $p < 0.05$ was statistically significant.

Results

Basic characteristics

Of the 228 children with spinal cord injury, 60 were boys and 168 were girls; 93 were aged 3–6 years and 135 were aged 6–18 years; 67 were nontraumatic and 161 were traumatic; 21 were in the neck segment, 179 were in the chest segment, 27 were in the waist segment, and 1 was in the sacral segment; the damage plane of C1 to T5 accounted for 24.6%, T6 to T12 accounted for 62.7%, L1 to L3 accounted for 11.4%, and below L4 accounted for 1.3%; in AISA grading, grade A accounted for 59.2%, grade B accounted for 12.3%, grade C accounted

for 9.6%, and grade D accounted for 18.9%; the use of assistive devices accounted for 86.4%; there were complications accounted for 85.5%; the Injury to recovery time interval ≤ 30 days accounted for 16.2%; the rehabilitation duration > 90 days accounted for 31.1%; children who could not walk accounted for 64.5%; UEMS and LEMS > 50 points accounted for 30.3%; the 6WMD(ASIA A)was 0.604 ± 8.523 m; the 6WMD(ASIA B) was 10.925 ± 19.884 m;.the 6WMD(ASIA C) was 184.423 ± 98.851 m; the 6WMD(ASIA D) was 316.126 ± 92.110 m.See Table 2.

Children's SCI functional independence outcome score

Of the 228 children tested, the discharge eating differential was 0.14 ± 0.396 points, the difference in bathing was 0.86 ± 0.915 points, the difference in dressing was 1.40 ± 1.476 points, and the difference in grooming was 0.70 ± 0.895 points. The respiratory difference was 0.51 ± 0.893 points, the sphincter management (bladder) difference was 0.91 ± 1.433 points, the sphincter management (intestine) difference was 0.23 ± 0.677 points, toilet use difference is 0.36 ± 0.709 points; bed mobility difference is 1.25 ± 1.342 points, bed-chair conversion difference is 0.14 ± 0.473 points, wheelchair-toilet-bath

Table 2 Basic characteristics of children with SCI from 2017 to 2021

Variables	Options	Frequency (*n*)	Percentage (%)
Gender	male	60	26.3
	female	168	73.7
Age	pre-school age (3 ~ 6 y)	93	40.8
	school age (6 ~ 18 y)	135	59.2
Cause of injury	non-traumatic	67	29.4
	traumatic	161	70.6
Injury segments	neck segment	21	9.2
	chest segment	179	78.5
	waist segment	27	11.8
	sacral segments	1	0.4
Damage plane	C1 ~ T5	56	24.6
	T6 ~ T12	143	62.7
	L1 ~ L3	26	11.4
	L4 below	3	1.3
AISA	A	135	59.2
	B	28	12.3
	C	22	9.6
	D	43	18.9
Assistive devices	no	31	13.6
	yes	197	86.4
complications	no	33	14.5
	yes	195	85.5
Injury to recovery time interval	≤ 30 d	37	16.2
	> 30 d	191	83.8
rehabilitation duration	≤ 90 d	157	68.9
	> 90 d	71	31.1
WISCI-II	Unable to walk	147	64.5
	Able to walk	81	35.5
UEMS and LEMS	≤ 50 p	159	69.7
	> 50 p	69	30.3
BI	Heavily Dependence	162	71.1
	Moderate Dependence	10	4.4
	Mild Dependence	56	24.6
6WMD(ASIA)			
A	0.604 ± 8.523 m	135	59.2
B	10.925 ± 19.884 m	28	12.3
C	184.423 ± 98.851 m	22	9.6
D	316.126 ± 92.110 m	43	18.9

Note: y: years; C1 ~ T5: cervical pulp ~ upper thoracic pulp; T6 ~ T12: middle and lower thoracic pulp; L1 ~ L3: middle and upper part of lumbar pulp; Below L4: lower lumbar pulp and sacral pulp; d: days; p: points; m: meters

Table 3 Results of admission, discharge and difference of SCI-III scale for children from 2017 to 2021

Project	Options	Admission	Discharge	Difference	*P* value
Self-care (0 ~ 20 points)	eating	2.75 ± 0.653	2.89 ± 0.515	0.14 ± 0.396	< 0.001
	take a bath	1.83 ± 1.953	2.69 ± 1.864	0.86 ± 0.915	< 0.001
	dressing and undressing	2.27 ± 2.155	3.67 ± 2.368	1.40 ± 1.476	< 0.001
	embellished	1.87 ± 1.087	2.57 ± 0.785	0.70 ± 0.895	< 0.001
Respiratory and sphincter management (0 ~ 40 points)	breath	8.51 ± 1.521	9.02 ± 1.347	0.51 ± 0.893	< 0.001
	bladder	7.30 ± 3.806	8.21 ± 3.778	0.91 ± 1.433	< 0.001
	bowel	2.48 ± 3.963	2.71 ± 4.287	0.23 ± 0.677	< 0.001
	using the toilet	1.02 ± 1.622	1.38 ± 1.966	0.36 ± 0.709	< 0.001
Move (indoors and in toilets) (0 ~ 40 points)	bed movement	3.82 ± 1.803	5.07 ± 1.583	1.25 ± 1.342	< 0.001
	bed-chair conversion	0.92 ± 0.685	1.06 ± 0.665	0.14 ± 0.473	< 0.001
	wheelchair-toilet-tub transition	0.35 ± 0.571	0.54 ± 0.704	0.19 ± 0.414	< 0.001
	indoor move	2.63 ± 2.039	3.05 ± 2.298	0.42 ± 0.767	< 0.001
	distance to travel (10 ~ 100 m)	2.60 ± 2.070	3.07 ± 2.324	0.46 ± 0.793	< 0.001
	outdoor move (> 100 m)	2.32 ± 1.712	2.95 ± 2.257	0.63 ± 1.081	< 0.001
	up and down stairs	0.36 ± 0.651	0.59 ± 1.031	0.24 ± 0.583	< 0.001
	transfer-to-car	0.30 ± 0.548	0.40 ± 0.679	0.10 ± 0.296	< 0.001
	ground-wheelchair	0.16 ± 0.365	0.20 ± 0.402	0.04 ± 0.244	< 0.001
Total score (0 ~ 100 points)		41.48 ± 4.089	50.05 ± 25.028	8.57 ± 7.000	< 0.001

Note: $p < 0.05$ was statistically significant

Table 4 Factors and assignments for SCI children, 2017 to 2021

Category of Factors	Factor assignment
Gender	male (1), female (2)
Age	3 to 6 (1), 6 to 18 (2)
Cause of injury	non-traumatic (1), traumatic (2)
Injury segments	neck (1), chest (2), waist (3), sacral (4)
Damage plane	C1 ~ T5 (1), T6 ~ T12 (2), L1 ~ L3 (3), L4 below (4)
AISA	a (1), b (2), c (3), d (4)
Assistive devices	no (1), yes (2)
Complications	no (1), yes (2)
Injury to recovery time interval	≤ 30 d (1), > 30 d (2)
Rehabilitation duration treatment	≤ 90 d (1), > 90 (2)
WISCI-II	unable to walk (1), able to walk (2)
UEMS and LEMS	≤ 50 p (1), > 50 p (2)
BI	severe (1), moderate (2), mild (3)
6WMD	≤ 150 m(1), >150 m(2)
Self-cares	Change (1), No change (2)
Respiratory and sphincter management	Change (1), No change (2)
Move	Change (1), No change (2)
SCIM-III	Original value input

Note: y: years; C1 ~ T5: cervical pulp ~ upper thoracic pulp; T6 ~ T12: middle and lower thoracic pulp; L1 ~ L3: middle and upper part of lumbar pulp; Below L4: lower lumbar pulp and sacral pulp; d: days; p: points; m: meters

transfer difference is 0.19 ± 0.414 points, indoor mobility difference is 0.42 ± 0.767 points, moderate distance movement difference of 0.46 ± 0.793 points, outdoor movement difference of 0.63 ± 1.081 points, up and down stairs difference of 0.24 ± 0.583 points, transfer-to-car transfer difference of 0.10 ± 0.296 points, ground-wheelchair transfer difference of 0.04 ± 0.244points.The total SCIM-III scale score differed by 8.57 ± 7.000points, which was statistically significant($p < 0.001$). Table 3.

Analysis of influencing factors of functional independence outcome of SCI in children

one-way ANOVA analysis

The values assigned to each factor are shown in Table 4. Self-care: injury segments, damage plane, ASIA, assistive devices, complications, rehabilitation duration treatment, WISCI-II, UEMS and LEMS, BI, and 6WMD groups were statistically significant ($p < 0.001$). Respiratory and sphincter management: injury segments, ASIA, complications, injury to recovery time interval, rehabilitation duration treatment, WISCI-II, UEMS and LEMS, BI, and 6WMD groups were statistically significant ($p < 0.05$). Move: age, injury segments, damage plane, rehabilitation duration treatment, WISCI-II, UEMS and LEMS groups were statistically significant ($p < 0.05$). SCIM-III total score: age, AISA, assistive devices, injury to recovery time interval, rehabilitation duration treatment were statistically significant ($p < 0.05$). See Table 5.

Multiple logistic regression analysis

The partial regression coefficients, standard errors, Wald/Beta, and significance results for the respective variables are presented in Table 6, which leads to the logistic regression equation: Self-care: $Y=-0.465-1.920_{x1}-2.186_{x2}-1.586_{x3}+2.550_{x4}$. Respiratory and sphincter management: $Y=-0.923+1.915_{x1}-0.845_{x2}-1.479_{x3}$. Move: $Y=-0.875+1.807_{x1}-3.224_{x2}-2.518_{x3}-4.106_{x4}$.SCIM-III:

Table 5 Results of one-way ANOVA on factors affecting functional independence of children with SCI

Variant		Self-cares			Respiratory and sphincter management			Move			SCIM-III
		No change Per (%)	Change Per (%)	*p*	No change Per (%)	Change Per (%)	*p*	No change Per (%)	Change Per (%)	*p*	*p*
Gender	1	33.3	24.7	0.253	22.5	29.9	0.205	75.0	73.3	0.797	0.595
	2	66.7	75.3		77.5	70.1		25.0	26.7		
Age	1	35.7	41.9	0.459	46.8	35.0	0.070	60.7	34.3	<0.001	0.022
	2	64.3	58.1		53.2	65.0		39.3	65.7		
Cause of injury	1	28.6	29.6	0.898	27.0	31.6	0.446	35.7	27.3	0.231	0.182
	2	71.4	70.4		73.0	68.4		64.3	72.7		
Injury segments	1	16.7	7.5	<0.001	5.40	12.8	0.007	21.4	5.2	0.001	0.297
	2	50.0	84.9		87.4	70.1		75.0	79.7		
	3	31.0	7.5		6.30	17.1		3.6	14.5		
	4	2.4	0.0		0.9	0.0		0.0	0.6		
Damage plane	1	23.8	24.7	<0.001	24.3	24.8	0.081	37.5	20.3	0.017	0.214
	2	42.9	67.2		68.5	57.3		58.9	64.0		
	3	28.6	8.1		6.3	17.1		3.6	14.5		
	4	4.80	0.0		0.9	0.9		0.0	1.2		
AISA	1	21.4	67.7	<0.001	70.3	48.7	0.002	69.6	55.8	0.289	0.012
	2	11.9	12.4		12.6	12.0		10.7	12.8		
	3	11.9	9.1		4.5	14.5		5.4	11.0		
	4	54.8	10.8		12.6	24.8		14.3	20.3		
Assistive devices	1	54.8	92.5	<0.001	89.2	82.1	0.126	85.7	85.5	0.963	0.018
	2	45.2	7.5		10.8	17.9		14.3	14.5		
Complications	1	33.3	9.1	<0.001	8.1	18.8	0.019	10.7	14.5	0.469	0.506
	2	66.7	90.9		91.9	81.2		89.3	85.5		
Injury to recovery time interval	1	14.3	16.7	0.705	6.3	25.6	<0.001	8.9	18.6	0.088	< 0.001
	2	85.7	83.3		93.7	74.4		91.1	81.4		
Rehabilitation duration treatment	1	90.5	64.0	<0.001	76.6	61.5	0.014	94.6	60.5	<0.001	< 0.001
	2	9.5	36.0		23.4	38.5		5.4	39.5		
WISCI-II	1	28.6	72.6	<0.001	79.3	50.4	<0.001	78.6	59.9	0.011	0.837
	2	71.4	27.4		20.7	49.6		21.4	40.1		
UEMS and LEMS	1	28.6	79.0	<0.001	82.0	58.1	<0.001	80.4	66.3	0.046	0.074
	2	71.4	21.0		18.0	41.9		19.6	33.7		
BI	1	31.0	80.1	<0.001	83.8	59.0	<0.001	82.1	67.4	0.100	0.185
	2	2.4	4.8		0.9	7.7		1.8	5.2		
	3	66.7	15.1		15.3	33.3		16.1	27.3		
6WMD	1	38.1	82.8	<0.001	82.9	66.7	0.005	80.4	72.7	0.252	0.153
	2	61.9	17.2		17.1	33.3		19.6	27.3		

$Y = 13.416 + 4.002_{x1} + 0.540_{x2} - 0.840_{x3} - 9.893_{x+4.245x5}$. See Table 6.

Discussion and recommendations

The guiding principles of rehabilitation in the health service system underscore its profound significance. Rehabilitation is not simply the treatment of disease, but also focuses on prevention and health promotion. The program assists patients in modifying detrimental behaviours and enhancing their overall physical and mental well-being through the provision of early intervention, educational resources, and training opportunities. Rehabilitation has been demonstrated to be an effective method for improving function, assisting patients in regaining lost function and achieving the optimal physical condition through the implementation of therapeutic measures such as physical therapy, occupational therapy, and speech therapy. Furthermore, rehabilitation facilitates social integration and assists individuals in surmounting challenges, reintegrating into society, and actualizing their potential through the provision of services such as social support, vocational training, and psychological counselling. The overarching objective of rehabilitation is to enhance the quality of life, thereby fostering a greater sense of well-being and fulfillment. This is achieved through a range of measures, including

Table 6 Results of multiple logistic regression analysis on factors affecting functional independence of children with SCI

Implicit variable	Factors	Partial regression Coefficient	Standard Error	Wald/Beta	*P*	OR	95%CI Upper and lower limits	
Self-care	Constant	-0.465	0.536	0.751	0.386	0.628	-	-
	Rehabilitation duration treatment (>90d)	-1.920	0.586	10.751	0.001	0.147	0.047	0.462
	Injury segments (chest)	-2.186	0.647	11.430	0.001	0.112	0.032	0.399
	Injury segments (waist)	-1.586	0.829	3.662	0.056	0.205	0.040	1.039
	UEMS and LEMS (> 50p)	2.550	0.520	24.041	< 0.001	12.806	4.621	35.488
Respiratory and sphincter management	Constant	-0.923	0.440	4.392	0.036	0.397	-	-
	Injury to recovery time interval(>30d)	1.915	0.468	16.713	< 0.001	6.784	2.709	16.988
	Rehabilitation duration treatment (>90d)	-0.845	0.322	6.876	0.009	0.429	0.228	0.808
	WISCI-II (walk)	-1.479	0.317	21.747	< 0.001	0.228	0.122	0.424
Move	Constant	-0.875	0.713	1.508	0.219	0.417	-	-
	Age	1.807	0.390	21.499	< 0.001	6.095	2.839	13.084
	Rehabilitation duration treatment (>90d)	-3.224	0.709	20.695	< 0.001	0.040	0.010	0.160
	Injury segments (chest)	-2.518	0.612	16.921	< 0.001	0.081	0.024	0.268
	Injury segments (waist)	-4.106	0.976	17.701	< 0.001	0.016	0.002	0.112
SCIM-III	Constant	13.416	1.701	-	< 0.001	7.888	10.064	16.768
	Age	4.002	0.802	0.282	< 0.001	4.989	2.421	5.583
	AISA classification	0.540	0.438	0.093	0.218	1.235	-0.322	1.403
	assistive devices	-0.840	1.515	-0.041	0.580	-0.555	-3.827	2.146
	Injury to recovery time interval	-9.893	1.072	-0.522	< 0.001	-9.229	-12.006	-7.780
	Rehabilitation duration	4.245	0.816	0.281	< 0.001	5.200	2.636	5.854

the reduction of symptoms, improvement of physical functioning, enhancement of psychological well-being, and promotion of social participation. The objective is to achieve a state of optimal functioning and well-being. In addition to the numerous advantages it offers patients, rehabilitation is also a cost-effective intervention. It has the potential to reduce the necessity for emergency hospitalization and urgent care, as well as unemployment and social welfare expenditures, through the provision of timely rehabilitation services. It is therefore evident that rehabilitation plays a pivotal role in the healthcare system, enhancing overall health and well-being for both individuals and society [15].

The one-way ANOVA revealed that age groups, Injury to recovery time interval, rehabilitation duration treatment, AISA, and the presence or absence of assistive devices were significant predictors of functional independence outcomes. However, the Multiple logistic regression analysis indicated that AISA and the use of assistive devices did not exert a direct influence on functional independence. The findings of this study indicate that a shorter interval between injury and rehabilitation, coupled with the age of the child, is associated with a longer rehabilitation treatment modify and a higher level of functional independence. Given that all of the subjects in this study had sustained a spinal cord injury (SCI), their cognitive abilities and level of cooperation were limited, and they were unable to provide accurate information about the relevant subjective data. The SCIM-III scale is a straightforward and highly feasible tool with greater significance in predicting the prognosis of children's functional independence outcomes. It can more accurately predict immediate and long-term rehabilitation goals and guide the further development of rehabilitation treatment programs.

Multiple logistic regression analysis of the Injury to recovery time interval was the main factor influencing functional independence outcomes in children with SCI. The ongoing advancement of medical technology has led to a growing recognition of the importance of rehabilitation in the treatment and rehabilitation process of SCI patients. Particularly in respiratory and sphincter management. The underlying mechanism action of early rehabilitation is to promote neuroplasticity, restore musculoskeletal function, regulate psychological factors, prevent complications, and improve the quality of daily life etc [16, 17]. Furthermore, Sumida et al. [18] investigated 123 patients with SCI across 17 Japanese rehabilitation facilities, demonstrating that acute-phase rehabilitation (2 to 6 weeks) was associated with enhanced motor function and an improved ability to perform activities of daily living. The data examined in this study revealed that the majority of children in this institution-initiated rehabilitation when their condition stabilised. This occurred approximately 4 to 5 weeks post-injury, as it was deemed preferable to avoid causing secondary injuries. Accordingly, the Injury to recovery time interval were dichotomized into subgroups, and multiple logistic regression analysis demonstrated that the change in functional independence was more pronounced in the children who

were engaged in rehabilitation at an early stage. Additionally, this study is consistent with the findings of Vander Putte et al. [19]who investigated the influence of various factors on functional independence outcomes following rehabilitation in non-traumatic spinal cord patients and observed a greater degree of similarity.

Multiple logistic regression analysis was performed to analyze the rehabilitation duration as a secondary factor influencing functional independence outcomes in children with SCI. A review of the literature reveals considerable variation in the duration of hospital-based rehabilitation therapy for individuals with spinal cord injuries (SCI), with reported periods ranging from a minimum of one month to a maximum of more than half a year [20, 21]. Moreover, the rehabilitation duration has a direct effect on the mental health of children. Prolonged rehabilitation can cause considerable psychological distress, which can affect emotional stability and self-confidence. In some cases, this can result in the emergence of psychological problems such as depression and anxiety [22, 23]. The data from this study's survey indicated that a three-month rehabilitation treatment cycle is standard practice at this hospital. Consequently, the length of time spent in hospital for rehabilitation was categorized into two groups. A multiple logistic regression analysis demonstrated that the duration of rehabilitation therapy had an indirect effect on the outcome of children's SCI function.

Multiple logistic regression analysis, in which age was a secondary factor influencing functional independence outcomes in children with SCI. It is well-documented that children's neurological and motor functions are undergoing constant development, the fact that rehabilitation outcomes are often more favorable than those observed in adults [24, 25]. However, children may encounter additional challenges following an injury, including a prolonged period of adaptation and rehabilitation. Additionally, children's cognitive comprehension and overdependence on their parents may also impact their functional independence [26, 27]. Therefore, children's age was dichotomized into subgroups, and multiple linear regression analyses demonstrated that age indirectly influences the outcome of functional independence in children with SCI.

Multiple logistic regression analysis, in which injury segments was a primary factor influencing the functional self-care and move aspects of children's SCI, and that the severity of the injury segment was closely associated with loss of function independence. Generally, a higher injury segment indicates a closer proximity to the brain, resulting in a more significant impact on motor and sensory functions. To illustrate this point, consider the consequences of a cervical cord injury, which can result in severe motor dysfunction due to the cervical cord as role as a major bundle of nerves controlling muscle movement in the upper and lower limbs and the trunk [28]. In contrast, injuries to the thoracic or lumbar medulla primarily affect lower limb movements and tend to have a lesser effect on upper limb and trunk function [29]. The present results demonstrate that the higher the injury segments, the more challenging the recovery process is likely to be. Conversely, the lower the injury segment, the greater the probability of recovery. However, these outcomes are also contingent on the regenerative capacity of the nerve bundle, the extent of the injury, and the promptness of treatment.

On one-way ANOVA, the AISA was correlated with functional independence outcomes for the children. Multiple logistic regression analysis showed no correlation between this factor and functional independence outcomes. This may indicate that the AISA rating scale may not a comprehensive representation of treatment outcomes after rehabilitation. Kisala and Meng et al. [30, 31] demonstrated that functional independence scores (including basic mobility, self-care, and mobility, among others) In patients with SCI who were hospitalized for rehabilitation, functional restoration was observed at discharge and follow-up. However, changes in mobility were more pronounced in patients with incomplete SCI, particularly in children with grades C and D. These findings are not consistent with the AISA. However, Van Middendorp et al. [32] demonstrated that an improvement in AISA grading was not significantly associated with enhanced functional mobility outcomes in patients with traumatic SCI. Their findings are more aligned with those of this study and require further corroboration through additional pertinent research in the future.

On one-way ANOVA, the presence or absence of an assistive device was correlated with the children's functional independence outcomes. Multiple logistic regression analysis of this influence factor did not correlate with functional independence outcomes. The rehabilitation of individuals with SCI to facilitate independent participation in society necessitates the formulation of individualized recommendations for mobility aids [33, 34]. It has been proposed that the judicious use of mobility aids is an important factor in functional recovery [35, 36]. The present investigation revealed a significant correlation between the use of assistive devices and both indoor and outdoor mobility, as measured by the SCIM-III scale [37]. However, the majority of the investigators were children with complete SCI who primarily resided independently in a wheelchair. Consequently, the observed changes in mobility scores may have been minimal. Indeed, the multiple regression analysis revealed no statistically significant correlation between the use of assistive devices and functional independence outcomes.

Pediatric SCI patients are at risk for a variety of complex and potential complications due to limited physical functioning as a result of neurologic injury and a prolonged bedridden or sedentary lifestyle. These complications "not only their physical health but may further exacerbate the decline in their quality of life, including the development of" pressure ulcers, deep vein thrombosis, urinary tract infections, osteoporosis, and scoliosis [38]. It is imperative that medical professionals underscore the significance of periodic assessment and surveillance for pediatric SCI patients and their families. This entails a comprehensive approach, encompassing regular evaluation of the skin condition, routine urinalysis, and other essential procedures. Concurrently, medical practitioners should educate patients and their families on a series of preventive measures, including regular position changes, appropriate exercise, and reasonable nutritional support, to effectively prevent or slow the occurrence of complications. Additionally, long-term rehabilitation training not only restores or improves damaged functions but also enhances the overall physical and mental health of the patient, such as cardiopulmonary function, body resistance, and abnormal body posture.

The overarching objective of rehabilitation for children with SCI is their reintegration into the educational and social fabric of their communities. While the rehabilitation program is primarily concerned with restoring physical function, it is equally focused on fostering social adaptability. Crucially, it provides an means for these children to establish a sense of belonging within their communities and to recognize their intrinsic value. The rehabilitation treatment program is designed to address the unique needs of children at every stage of growth. Some hospitals have introduced advanced rehabilitation technologies and methods, such as virtual reality training and robot-assisted walking training [39, 40], with the objective of stimulating children's potential abilities and accelerating their integration into school and society. Secondly, the development of social adaptability functions as a conduit between children and their integration into the school or wider society. Community activities, such as participation in public welfare programmes, cultural mini-classroom experiences, and outdoor group activities, have been shown to facilitate the development of social skills and enhance teamwork in children. These activities can also foster a sense of belonging and tolerance within society. Furthermore, we proactively collaborate with educational institutions to guarantee that SCI children have the opportunity to receive an education on an equal footing, engage in campus activities, and develop alongside their peers. Ultimately, the advancement of public education and the cultivation of social awareness regarding spinal cord injury (SCI) represent the foundation for the creation of a barrier-free social environment. Through a multifaceted approach encompassing media publicity, public welfare activities, and policy advocacy. With the objective of disseminating knowledge about SCI, fostering a greater understanding and respect for the rights and needs of individuals with SCI. This, in turn, will facilitate the development of a more inclusive and welcoming social environment.

It is important to note that lifelong rehabilitation is a crucial aspect of the treatment plan for pediatric SCI patients [41, 42]. The spinal cord serves is a vital neural pathway, linking the brain to all regions of the body. Injury to this structure frequently results in a range of dysfunctions, including motor, sensory, respiratory, bladder, and bowel control impairments. The rehabilitation of spinal cord injuries in children is a complex and lengthy process that necessitates comprehensive interventions across multiple domains. By restoring and improving function, preventing complications, focusing on mental health, fostering self-care ability, and promoting school and social integration, the impact of spinal cord injuries on children and their families can be minimized, and the potential for hope and joy in life can be restored. Concurrently, with the progression of medical technology, including the investigation of novel therapies such as neuromodulation and stem cell therapy, which present a promising avenue for functional recovery from spinal cord injury, sustained rehabilitation has emerged as a crucial strategy for achieving this objective.

It should be noted that this study is not without limitations. First, only children with SCI who underwent rehabilitation during their hospitalization were selected for this study, and detailed information was not collected for children who did not undergo rehabilitation in the pediatric physical therapy unit during their hospitalization. Secondly, this study was a single-center retrospective survey study with issues such as bias and missing data, and a low level of clinical evidence. Further prospective studies are required to validate the results of this study. Finally, the present study was found to be incomplete, with a paucity of data regarding the subsequent care of the children following their discharge from hospital. It is recommended that future studies concentrate on the long-term rehabilitation of spinal cord injuries in children.

Conclusions

The shorter the interval between the time of injury and the time of intervention and rehabilitation, the more favorable the child's functional recovery. Conversely, the longer the period of rehabilitation after the child's admission to the hospital, the greater the functional independence. It is recommended that the rehabilitation intervention time for children with SCI in this hospital should be initiated as early as possible and that rehabilitation should be adhered to for an extended period of time.

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Author contributions
Z.H.B., R.X.J., Z.Q., conceived the study. Z.H.B. takes responsibility for the paper as a whole. R.X.J., Z.Q., M.T.T., H.Y., Z.T.T., Z.Y.Q. helped with implementation, data collection, and drafting of the manuscript. Z.H.B. performed data analysis. Z.Q.Corresponding authorZ.H.B.performed contributing.All authors contributed substantially to manuscript editing and revision.

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Data availability
Data is provided within the manuscript "The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restriction."

Declarations

Ethics approval and consent to participate
This study was reviewed and approved by the Ethics Committee of China Rehabilitation Research Center (Approval No. 2024IIT–61). All procedures involving human participants were conducted in accordance with the ethical standards of the Declaration of Helsinki (2013 revision).

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests. For minors under the age of 16, written and verbal informed consent was obtained from their parents or legal guardians before initiating this research activities. The consent process included a detailed explanation of the study's purpose, potential risks, and benefits, ensuring compliance with both institutional guidelines and international ethical norms.

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