

Quantitative Functional Recovery Assessment of Spinal Cord Injury by using “Spinal Cord Injury- Ability Realization Measurement Index (SCI-ARMI)”: An Observational Study

Dharmika M. Koyani¹, Jayshree Sutaria²

¹M.P.T. (Neurosciences), Gujarat University, Ahmedabad, Gujarat, India

²M.P.T., Ph.D., Senior Lecturer, Government Spine Institute and Government Physiotherapy College, Civil Hospital, Asarwa, Ahmedabad, Gujarat, India

Corresponding Author: Dharmika M. Koyani

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ABSTRACT

Background: Spinal cord injury (SCI) refers to a physical injury to the spinal cord that distorts normal spinal cord function. The sudden occurrence of SCI leading to paralysis of the muscles below the level of injury leads to major functional limitations. Thus, the Spinal Cord Injury- Ability Realization Measurement Index (SCI-ARMI) tool was developed that evaluates functional recovery quantitatively.

Purpose: To assess changes in quantitative functional recovery before and after rehabilitation of spinal cord injury by using Quadric Formula of SCI-ARMI.

Methodology: SCI-ARMI was used as an outcome measure. Participants followed a routine conventional approach. They were assessed before starting inpatient rehabilitation and after 4 weeks of inpatient rehabilitation by taking Spinal Cord Independence Measure version III (SCIM-III) and AIS motor score (AMS) along with age and gender as a factor for calculation of SCI-ARMI.

Results: A highly significant difference was found with a p-value of <0.001. That is suggestive of significant changes in SCI-ARMI scores before and after conventional rehabilitation. Change in this score and improvement in functional performance was influenced by the conventional approach of inpatient rehabilitation.

Conclusion: The present study concludes that SCI ARMI is useful and effective tool that monitors achievement of rehabilitation potential

and helps to observe changes in quantitative functional recovery in individuals with SCI.

Clinical Implication: SCI-ARMI is valid and reliable tool and also takes less time for calculation that can be incorporated into routine clinical assessment for the evaluation of functional performance and rehabilitation potential in SCI population.

Keywords: SCI-ARMI, Quantitative Functional Recovery, Spinal Cord Injury.

INTRODUCTION

Spinal Cord Injury (SCI) refers to an injury to the spinal cord that distorts normal spinal function.^{1,2} It is a rare occurrence and high-cost injury which makes the individual dependent on others.³ This injury ends up in a tremendous change in an individual's life.³ As reported by the world health organization (WHO), every year 250000-500000 people suffer from SCI worldwide.⁴ As stated by WHO, the incidence of SCI is increasing in developing countries including India.^{5,6} The average annual incidence of SCI in INDIA is 15,000 with a prevalence of 0.15 million.⁷ The abrupt occurrence of SCI leads to major functional limitations which cause a major public health challenge.^{8,6}

Able-bodied adults can perform well-coordinated movements because of strong arms and legs and also have a good sense of balance when sitting, walking or moving.^{9,2}

and they balance upright when sitting or standing and simultaneously control the skilled movements of upper limbs during a functional task usually done automatically which is become challenging who have SCI.^{10,2} Therefore, clinical functional evaluation is an important part that helps the therapist about the functional status of the patient, recovery in functional performance as well as helps the therapist to identify and modify the plan of treatment as per requirement.¹¹

Usually, the Barthel Index (BI), the Modified Barthel Index (MBI), the Functional Independence Measure (FIM), the Quadriplegia Index of Function (QIF), and the Spinal Cord Independence Measure (SCIM) outcome measures are used to evaluate functional performance or functional recovery after SCI. Existing instruments cannot measure functional recovery quantitatively directly because they assess disability without eliminating the functional performance components that are directly affected by the neurological deficit.¹¹ The Spinal Cord Injury- Ability Realization Measurement Index (SCI-ARMI) is a new measure that is based on the spinal cord independence measure (SCIM), which evaluates the success of rehabilitation and the

rehabilitation potential of SCI patients after controlling for their clinical (motor scores) and demographic (gender and age) factors.^{11,12} The SCI-ARMI score is the ability realization that is expressed as a percentage.¹³

SCI-ARMI was first developed in 2004 at the spinal department of Loewenstein Rehabilitation Hospital, Israel and after that various versions of SCI-ARMI have been developed.^{11,13} For any level of severity of SCI, ability realization is defined as the ratio of the observed and maximum possible performance of daily living activities.¹³

For forming the SCI-ARMI, the 95th percentile of SCIM-III values (SCIM 95) at discharge from rehabilitation was used to deliver a conservative estimate of the maximum possible performance of daily activities for each ASIA Motor Score (AMS) value. The original quadric model for the SCIM95, which was a function of AMS alone, was continued by adding age at admission to rehabilitation and gender as a factor. Statistically significant effects on the SCIM95 ($P>0.03$) were found after these additions, and there were no interactions with AMS or between age and gender.¹³ In this formula, 1 for female participants and 0 for male participants were inserted.¹⁴

$$\text{SCI-ARMI: } \frac{100 \times \text{SCIMob}}{\text{SCIM95}}$$

$$\text{SCI - ARMI: } \frac{100 \times \text{SCIMob}}{26.0 - [0.00427 \times (\text{AMS}^2)] + [1.236 \times \text{AMS}] - [0.127 \times \text{Age}] - 3.7 \times \text{Gender}}$$

SCI-ARMI is the instrument that evaluates quantitative functional recovery which is independent of neurological deficits. Limited literature is available about the evaluation of quantitative functional recovery by using the SCI- ARMI formula in the Indian population. This study aims to assess functional recovery quantitatively by using SCI-ARMI.

NEED OF THE STUDY:

Functional Performance is the major problem that affected the patient with SCI which makes the patient dependent on the most

basic needs of daily activities like feeding, dressing, bathing, grooming, moving, transfer and other activities of daily living. This ultimately causes participation restrictions. There are many tools used to assess functional recovery after SCI but minimal use of the SCI-ARMI tool is found. There are very few studies found to be done on SCI-ARMI for quantitative measure of functional recovery and rehabilitation potential after SCI in the Indian population. So, the need of the study is to assess quantitative functional recovery after

rehabilitation of SCI by using the Quadric formula of SCI-ARMI.

OBJECTIVES:

- To assess changes in **quantitative functional recovery** before and after rehabilitation of spinal cord injury by using **Quadric Formula of SCI-ARMI**.

HYPOTHESIS:

H₀ NULL HYPOTHESIS:

- There is no significant change in quantitative functional recovery assessment of SCI-ARMI after rehabilitation of spinal cord injury.

H₁ ALTERNATIVE HYPOTHESIS:

- There is significant change in quantitative functional recovery assessment of SCI-ARMI after rehabilitation of spinal cord injury.

MATERIALS & METHODS

- **STUDY DESIGN:** An Observational Study.
- **STUDY SETTING:** At Physiotherapy Department (Indoor Patient)
- **STUDY DURATION:** 1 year
- **SAMPLING TECHNIQUE:** Purposive Sampling
- **SAMPLE SIZE:** 30. Based on ¼ number of subject's admission in one year. 120 subjects per year were assumed. Thus, the sample size was 30. The dropout rate was kept at 20%.

INCLUSION CRITERIA:

- Both males and females willing to participate in the study were included. Subjects aged >18 years, diagnosed with traumatic or non-traumatic spinal cord injury by the medical practitioner with the duration of < 6 months and who are able to sit were included. Subjects with all levels of the lesion and ASIA Grade A, B, C, and D were allowed to participate in the study. Conservative or operated are both included after being allowed by the medical practitioner.

EXCLUSION CRITERIA:

- Subjects with concomitant impairments such as other UMN LESION, head injury, unstable cognitive function & mental function, or any condition (other than one caused by SCL) that might influence their everyday function and subjects with additional musculoskeletal, neurological and cardio-pulmonary problems were excluded.

WITHDRAWAL CRITERIA:

- If the subject wants to withdraw from this study and if treatment is stopped within 4 weeks or the subject is discharged.

OUTCOME MEASURES:

- **SCI-ARMI** (Spinal Cord Injury- Ability Realization Measurement Index)

MATERIALS USED IN THE STUDY:

1. Consent form
2. Pen and paper
3. Assessment form
4. Spinal cord independence measure-III (SCIM-III) sheet
5. ASIA scale sheet
6. Plinth
7. Digital camera
8. Laptop
9. Mask, Gloves and Sanitizer

PROCEDURE:

Ethical approval for the present study was taken from the institutional ethical committee. Subjects diagnosed with spinal cord injury by medical practitioners were screened for the inclusion and exclusion criteria. A total of 40 subjects were evaluated, out of which 36 Subjects fulfilled the inclusion and exclusion criteria and participated in the study.

Subjects were explained the entire study procedure in their understandable language and then written informed consent was taken from the Subjects before starting the study. SCI-ARMI was used as an outcome measure. Subjects were assessed by using SCIM-III and AMS along with age and gender for

calculation of SCI-ARMI before starting inpatient rehabilitation and after 4 weeks of inpatient rehabilitation. SCI-ARMI score was calculated online on the SCIM Web site.¹⁵ Subjects followed a routine

conventional rehabilitation program. Out of 36 Subjects, 6 dropped out from this study due to early discharge. So, data analysis of 30 Subjects was done.

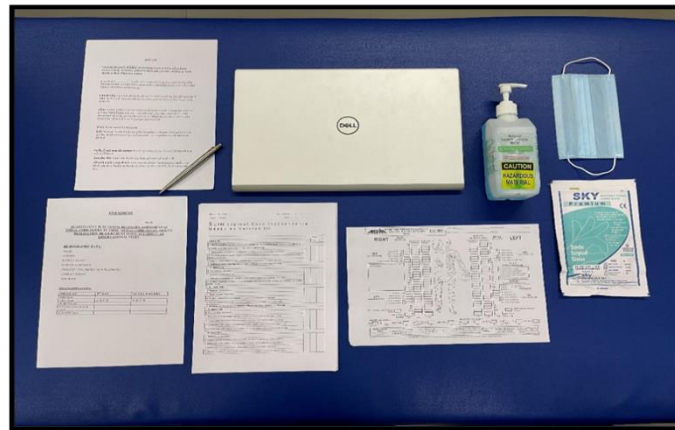
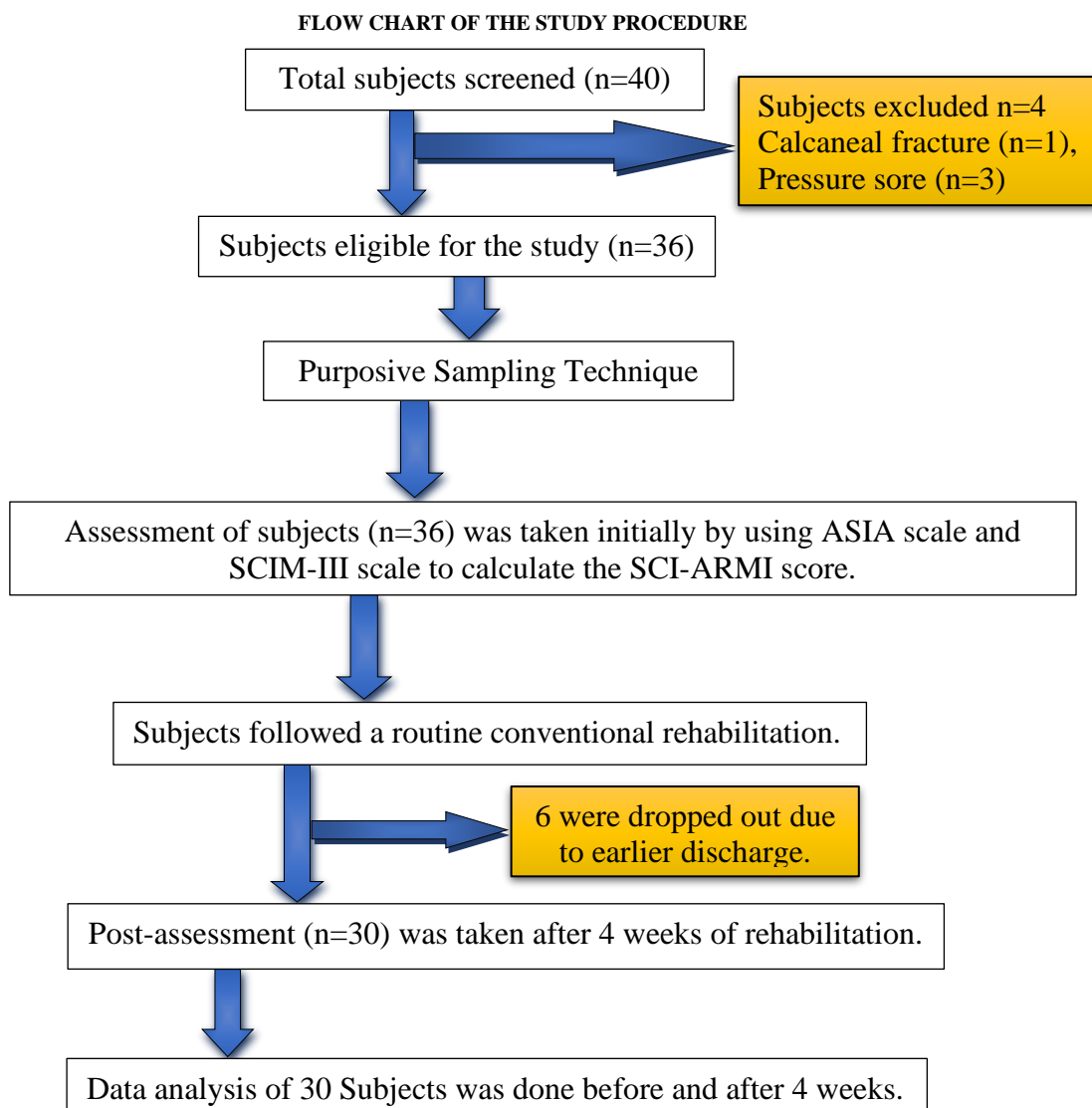


FIGURE-1: Materials used in the study.



Statistical Analysis

Data were analyzed using Statistical Packaging for Social Sciences version 28 (SPSS v.28.0) Microsoft Excel version 2019. The data was screened for the normal distribution using the Kolmogorov Smirnov test and Shapiro Wilk test. The data of SCI-ARMI was normally distributed so a parametric test was applied. The analysis was done before and after 4 weeks. The confidence interval was kept at 95%.

RESULT

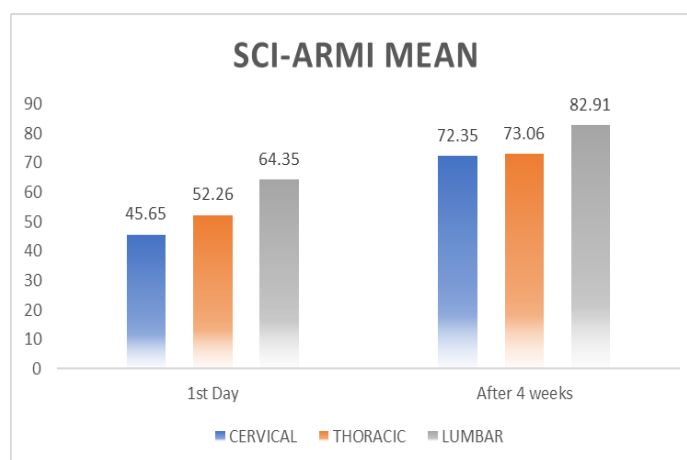
The present study was done to assess functional recovery quantitatively by using the SCI- ARMI formula. A total of 30 participants have completed the study. Table-1 provides information on subject characteristics observed in the present study. In gender distribution, there was 26 male and 4 female. Overall, there were a higher number of male participants compared to females. The mean age was 40.53 ± 14.96 years. (Median 40.5, range (19; 78))

Table 1: Patient Characteristics.

TOTAL SAMPLE (n=30)	
Socio-Demographic	
Age Mean± S. D	40.53± 14.96
Duration (Days) Mean± S. D	66.93± 49.81
Gender	
Male n (%)	26 (86.67%)
Female n (%)	4 (13.33%)
Lesion Characteristics	
Traumatic n (%)	26 (86.67%)
Non-Traumatic n (%)	4 (13.33%)
Asia Grade	
A n (%)	6 (20.00%)
B n (%)	4 (13.33%)
C n (%)	8 (26.66%)
D n (%)	12 (40.00%)
Lesion Level	
Cervical n (%)	14 (46.67%)
Thoracic n (%)	10 (33.33%)
Lumbar n (%)	6 (20.00%)

TABLE 2: SCI-ARMI MEAN DEPENDING UPON THE LEVEL OF LESION

LEVEL OF LESION	SCI-ARMI ASSESSMENT SCORE (%)			
	1 ST DAY		AFTER 4 WEEKS	
	MEAN	SD	MEAN	SD
CERVICAL	45.65	16.61	72.35	15.95
THORACIC	52.26	16.07	73.06	17.65
LUMBAR	64.35	14.74	82.91	12.16



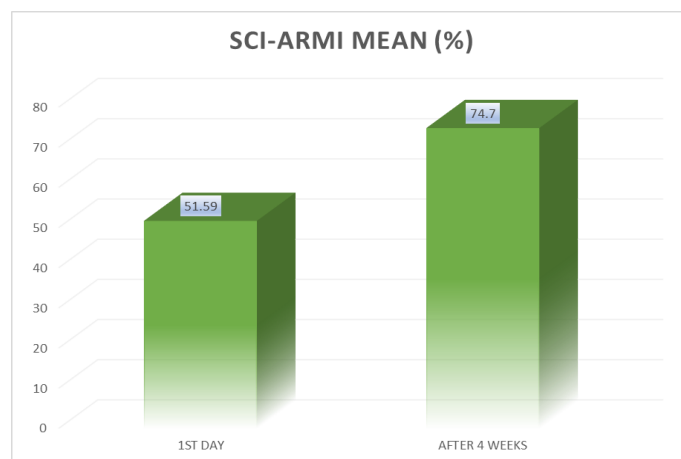
Graph-1: SCI-ARMI mean depending upon the level of lesion.

Table-2 and Graph-1 Showing of changes in SCI-ARMI mean depending upon the level of lesion. The mean SCI-ARMI percentage before rehabilitation and after 4 weeks was analyzed. SCI-ARMI score was increased after 4 weeks which was termed as SCI-ARMI gain. The mean of SCI-ARMI gain was $23.11 \pm 1.16\%$. <50% of subjects

exceeded 80% SCI-ARMI score in 4-week duration.

TABLE-3: MEAN SCI-ARMI SCORE OF 1ST DAY AND AFTER 4 WEEKS

SCI-ARMI ASSESSMENT SCORE (%)	MEAN	SD	P-value (2 tailed)
1 ST DAY	51.59	17.09	<0.001
AFTER 4 WEEKS	74.70	15.93	



Graph-2: Mean SCI-ARMI Score of 1st Day and After 4 Weeks.

Table-3 and Graph-2 shows that there is an increase in SCI – ARMI percentage after 4 weeks. To analyze changes in the SCI-ARMI score, Paired t-test was applied. P- value (2 tailed) was <0.001. Analysis showed a highly significant difference in SCI-ARMI scores which suggested that there is a significant change in quantitative functional recovery after 4 weeks.

Hence, the null hypothesis was rejected.

DISCUSSION

The goal of the present study was to assess functional recovery quantitatively after rehabilitation of SCI by using the quadric formula of SCI-ARMI.

The major finding of the present study was that, there was a highly significant change in SCI-ARMI scores ($p = <0.001$). which suggested that there is a significant change in quantitative functional recovery scores after 4 weeks of the inpatient rehabilitation program. Change in this score and improvement in functional performance was influenced by the conventional approach of inpatient rehabilitation.

G Scivoletto et al. conducted a study to apply the newest version of the SCI-ARMI to a group of patients to evaluate the extent of their ability realization and examine the clinical factors which influence the realization of their rehabilitation potential. They reported that the SCI-ARMI is an effective tool that can be used to measure the achievement of rehabilitation potential in

SCI patients and to identify patients who are at risk of not achieving their rehabilitative potential.¹³

Various disability rating scales BI, MBI, FIM, QIF, and SCIM have been proposed. These scales are used to evaluate SCI patients on admission and during the course of rehabilitation, assess treatment efficacies and weigh the burden of care.^{16-18,13} These tools were designed for the assessment of a variety of disabilities and are not sufficiently sensitive for specific changes in the ability of patients with SCI. For example, the FIM includes scoring of cognitive functions, which are usually intact in SCI patients, and provides a relatively low weight to sphincter management and mobility.^{19,11} However, despite its wide acceptance these scales are unable to assess the disability independent from the neurological deficit and thus evaluate the independent value of rehabilitation in improving function beyond the effects of neurological recovery.^{20-22,13}

To overcome this problem, the SCI-ARMI, based on the SCIM, was developed and first published in 2004. To detect changes in functional performance which are independent of neurological changes, constituting a new approach to quantitating the prospect and success of rehabilitation. The initial version of the SCI-ARMI merely adjust the relationship between SCIM and AIS motor scores.¹¹ However, this initial version was having several limitations which reduced the relevance, accuracy, and stability

of the formula.¹⁴ Further studies were done which used 95 percentile of SCIM-III and AMS along with age and gender for the development of SCI-ARMI that is known as the quadric formula of SCI-ARMI. This quadric model is relevant, accurate, stable and valid internationally.

Scivoletto et al. conducted a study to further develop the original formula of SCI-ARMI. In their study, they observed that the previously published model, which yielded similar SCIM95 values in all the countries, after adjustment for age and gender. Without this adjustment, however, only 86% of the non-Israeli SCIM III observations were lower than those SCIM95 values ($P < .0001$). based on their study, they reported that the original quadratic SCI-ARMI formula is valid for an international population after adjustment for age and gender. The new formula considers more factors that affect functional ability following SCI.¹⁴

The present study supports that there were significant changes in SCI-ARMI scores and it provides an estimate of quantitative changes in the functional recovery of subjects with SCI.

CONCLUSION

The present study concludes that SCI ARMI is a useful and effective tool that monitors the achievement of rehabilitation potential and helps to observe changes in quantitative functional recovery in individuals with SCI and identifies patients who are at risk of failing to accomplish their rehabilitative potential.

CLINICAL IMPLICATION

SCI-ARMI is valid and reliable tool and also takes less time for calculation that can be incorporated into routine clinical assessment for the evaluation of functional performance and rehabilitation potential in the SCI population.

LIMITATIONS

A Longer follow-up after 4 weeks of rehabilitation was not studied. Factors like etiology, level of lesion, complications and

ASIA grade that might influence the SCI-ARMI scores were not analyzed. Thus, these factors should be taken into account in the future study.

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Conflict of Interest: None

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Ethical Approval: Ethical approval was taken from the Institutional Ethical Committee.

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