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FUNCTIONAL ASSESSMENT METHODS FOR SPINAL CORD INJURY PATIENTS IN REHABILITATION PROCESS – A SYSTEMATIC REVIEW

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ABSTRACT

Background: Spinal cord injury (SCI) leads to neurological damage that causes motor, sensory and autonomic neurologic functions decrease and/or loss. Evaluating the functionality of persons with SCI, especially in cases of incomplete injury, requires professional experience and skill. Objectives: This study aimed to gain a systematic overview of the functional assessment methods for SCI patients in the rehabilitation process. Search Methods: Systematic electronic searches were carried out using different databases from which 3489 registers were retrieved. Selection criteria: Studies that used tools to evaluate patients with SCI motor function as the manual test, Graded and Redefined Assessment of Strength, Sensibility, and Prehension (GRASSP), ASIA Impairment Scale (AIS), Neuromuscular Recovery Scale (NRS), Walking Index SCI (WISCI), Walking Index SCI II (WISCI-II), functional independence measure (FIM) or Spinal Cord Independence Measurement III (SCIM-III). Reviews, animal studies, articles with more than ten years, theses and dissertations and/or out of the object of study were excluded. Data collection and analysis: Two experienced professionals searched the databases. All titles were read for the first selection. Afterward, the abstracts were read, and another number of articles were excluded. In the end, ten articles met the inclusion criteria of this study. Main results: We identified different tools used for the functional assessment of SCI persons, but 9 out of 10 studies did not detail the results by segment, and none presented a manual test for trunk evaluation. Robotic therapy combined with conventional therapy brings good results. Final Considerations: Ten studies that met inclusion criteria were identified. It was noticed that more in-depth studies are needed detailing the tests by segment, especially on trunk functionality in people with different levels of SCI.

Keywords: Functional Assessment Methods. Spinal Cord Injury. Rehabilitation.

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INTRODUCTION

Spinal cord injury (SCI) leads to neurological damage that causes motor, sensory and autonomic neurologic functions decrease and/or loss. Functional evaluation of SCI subjects, especially for incomplete injury, requires professional experience and skills. A detailed evaluation allows choosing better procedures in the rehabilitation process. Manual assessment is important, and other resources and protocols, used individually or together, contribute to a more realistic view of the functional possibilities of the person with SCI. The rehabilitation goal in people with SCI is to optimize functioning and better conditions in daily life.

Rehabilitation professionals must be deeply informed on people's functioning to guide the best decision-making about rehabilitation tools. For example, how much the rehabilitation process may optimize the affected function will be influenced by injury level and height. But it will also depend on the therapists' knowledge and understanding of patient's motor conditions (Hodel et al., 2020).

Thus, there is a real need for in-depth knowledge of reliable and sensitive methods that can be used to choose the best tools during the rehabilitation of SCI subjects. The International Standards for Neurological Classification of Spinal Cord Injury (ISNSCI) is an examination used to score the motor and sensory impairment developed by American Spinal Injury Association (ASIA) experts.

In daily rehabilitation and/or studies, the ISNSCI may be used as a classification tool to sensory and function levels (Behrman et al., 2012a, Buehner et al., 2012). Grasse et al. (2019) highlight that insightful measurement may provide a better basis for decision making. Thus, different tests, including new technologies, may provide greater precision to functional evaluation (Grasse et al., 2019).

Another valuable tool for the therapist is the Spinal Cord Independence Measurement (SCIM), an impairment rating scale explicitly developed for the functional assessment of SCI persons (Bluvshtein et al., 2011). In addition, the Graded and Redefined Assessment of Strength, Sensibility and Prehension (GRASSP) is a valid, reliable, standardized tool to measure upper limb impairment for cervical SCI through three domains: strength, sensation, and prehension (Jung et al., 2019).

This study aimed to obtain, through a systematic review, information about the methods used, how detailed are the functional evaluations and the use of technology to functional assessment in SCI patients during the reabilitation process.

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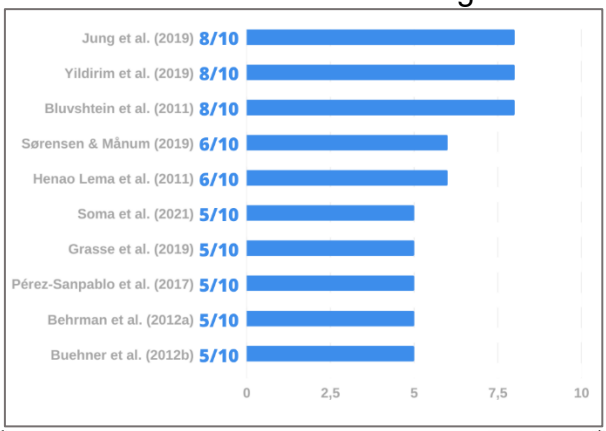
METHODOLOGY

This systematic review searched for studies that analyzed functional assessment methods in SCI subjects. The guiding question ('what are the methods used for the functional assessment of people with SCI in the rehabilitation process'?) was explored with the PICO tool ([P]opulation: SCI subjects; [I]ntervention: functional assessment methods; [C]omparison: no application of functional assessment; [O]utcome: observe the objectives and relationship with the results obtained for the various purposes).

The search was performed in PubMed, Springer, MEDLINE, Capes Platform, Cochrane, Elsevier, PEDro, ProQuest, SciELO, BVS and Google Scholar in Portuguese, English and Spanish. The searches were carried out from June 2021 to February 2022 with the following expression: "functional assessment methods" AND "spinal injury" AND "rehabilitation". Two reviewers independently screened the selected database, article titles, abstracts and full texts. Disagreements were resolved by a third reviewer.

Studies using tools to assess the motor function of SCI subjects such as Graded and Redefined Assessment of Strength, Sensibility, and Prehension (GRASSP), ASIA Impairment Scale (AIS), Neuromuscular Recovery Scale (NRS), Walking Index SCI (WISCI), Walking Index SCI II (WISCI-II), functional independence measure (FIM), Spinal Cord Independence Measurement III (SCIM-III), and manual test were selected. Reviews, conference papers, books, theses, articles with animals or whose focus was not the subject of this investigation, and those published over 10 years ago were also excluded.

Graphic 1- PEDro Studies Methodological evaluation



1. eligibility criteria were specified? 2. subjects were randomly allocated to groups? 3. allocation was concealed? 4. the groups were similar at baseline regarding the most important prognostic indicators? 5. there was blinding of all subjects? 6. there was blinding of all therapists who administered the therapy? 7. there was blinding of all assessors who measured at least one key outcome? 8. measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups? 9. all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"? 10. the results of between-group statistical comparisons are reported for at least one key outcome? 11. the study provides both point measures and measures of variability for at least one key outcome?

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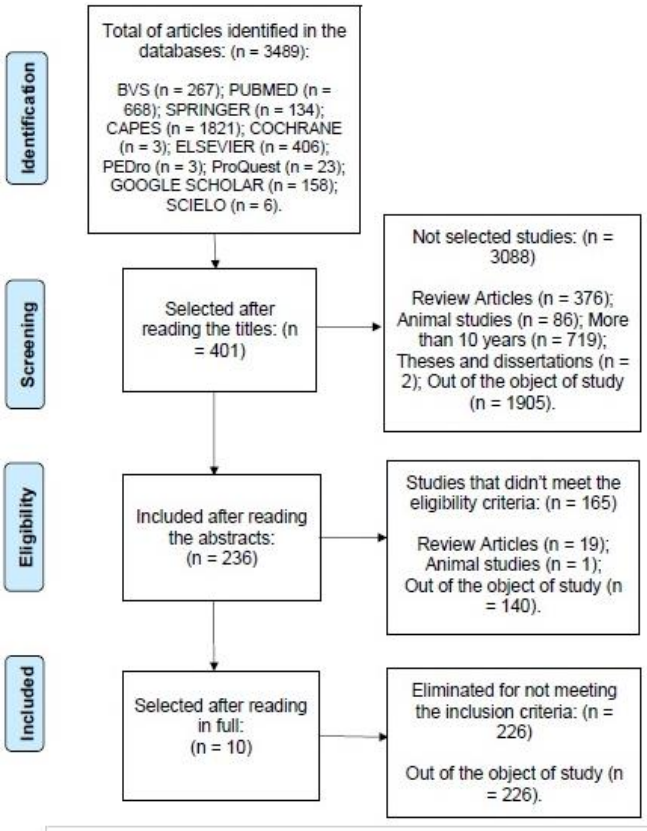
An individual assessment scale (Physiotherapy Evidence Database - PEDro) was applied to the selected studies, using the standardized form available on the digital platform that helps in the classification of possible bias, as shown in the graphic 1.

RESULTS

After retrieval, selection and exclusion phases, 10 articles were selected for this study, as shown in graphic 1, that shows the results from the PEDro scale analysis. The results showed the following paper distribution by year: 2019 (3), 2018 (1), 2017 (2), 2012 (2), and 2011 (1). Nines articles were in English and one in Spanish.

Figure 1 – PRISMA flowchart for article selection and exclusion criteria



Four articles were selected from Pubmed, 3 from BVS, 1 from CAPES and 2 from Google Scholar. Two journals contributed with 2 papers each (Archives of Physical Medicine Rehabilitation and Spinal Cord Series and Cases, whereas others contributed with 1 paper (Annals of Rehabilitation Medicine, Journal of NeuroEngineering and Rehabilitation, Turkish Journal of Medical Sciences, World Neurosurgery, Spinal Cord, and Revista Ciencias de La Salud (Table 1).

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Table 1 – studies data: Journals, volunteers and evaluation methods

Reference	Jung *et al.* (2019)	Sorensen & Manum 2019	Grasse *et al.* (2019)	Yildirim *et al.* (2019)	Behrman *et al.* (2019)	Buehner *et al.* (2012)	Bluvshtein *et al.* (2011)	Henao Lema *et al* (2011)	Soma *et al.* 2021	Perez-Sanpablo *et al.* (2017)
Language	English	English	English	English	English	English	English	Spanish	English	English
Data Base	Pubmed	Pubmed	Pubmed	Pubmed	BVS	BVS	BVS	CAPES	Google Scholar	Google Scholar
Magazine Where It Was Published	Annals of Rehabilitation Medicine	Spinal Cord Series And Cases	Journal Of Neuroengineer ing And Rehabilitation	Turkish Journal Of Medical Sciences	Arch Phys Med Rehabil	Arch Phys Med Rehabil	Spinal Cord Series And Cases	Revista Ciencias De La Salud	World Neurosurgery	Spinal Cord
Number Of Subjects Evaluated	30	4	13	88	95	225	261	45	21	23
Volunteers' Gender	Both		Both		Both	Both		Both	Both	
Etiology	Not Informed	Not Informed	Traumatic	Traumatic And Non - Traumatic	Traumatic (More Than One Option)	Not Informed	Not Informed	Trauma (More Than One Option)	Traumatic	Not Informed
Complete, Incomplete Or Both	Both	Incomplete	Both	Both	Incomplete	Incomplete	Not Informed	Both	Both	Not Informed
Cervical	30	4	13	18	72	166	Not Informed	11	3	6
Thoracic	0	0	0	19	23	59	Not Informed	29	10	17
Lumbosacral	0	0	0	53	0	0	Not Informed	5	8	0
Asia A	3	3	1	Not Informed	0	0	Not Informed	32	10	0
Asia B	4	0	4	Not Informed		0	Not Informed	13 (B+C+D)	1	0
Asia C	7	1	3	Not Informed	31	57	Not Informed	13 (B+C+D)	7	0
Asia D	8		1	Not Informed	64	167	Not Informed	13 (B+C+D)	3	23
Method Used - Manual	✓	✓	x	x	✓	✓	x	✓	x	x
GRASSP	✓	✓	✓	x	x	x	x	x	x	x
Asia - Complete Protocol	✓	x	✓	x		✓	x	✓	✓	x
Asia - Partial Protocol	x	✓		x	x	x	x	x	x	x
Neuromuscular Recovery Scale (Nrs)	x	x	x	x	x	x	x	x	x	x
Walking Index SCI II (Wisci-II)	x	x	x	✓	x	x	x	x	✓	✓
Functional Independence Measure (Fim)	x	x	x	✓	x	x	✓	x	x	x
SCI Measurement III (Scim-III)	✓	✓	x	x	x	x	✓	x	x	x
Dynamometer	✓	x	✓	x	x	x	x	x	x	x
Method Used -Electronic	x	x	✓	x	x	x	x	x	x	x
Upper Limbs Evaluation	✓	✓	✓	x	✓	✓	✓	✓	✓	x
Lower Limbs Evaluation		x	x	✓	✓	✓	✓	✓	✓	x
Trunk Evaluation	x	x	x	x	✓	✓	✓	✓	✓	x
Gait Evaluation	x	x	x	✓	✓	✓	✓	x	x	✓
Qualitative, Quantitative Analysis Or Both	Both	Both	Both	Both	Both	Both	Qualitative	Qualitative	Both	Both
Duration Of Study/Intervention	5 Months	6 Weeks	4 Months	2 Months	20 Sessions	Each 20 Sessions	Evaluation Only	Evaluation Only	12 Weeks	Evaluation Only
Before	✓	✓	✓	✓	✓	✓	x	x	✓	✓
During The Application Of The Protocol	x	✓	✓	✓	✓	✓	x	x	x	x
After	✓	✓	✓	✓	✓	✓	x	x	✓	✓

The number of participants in the included studies ranged from 4 to 261. One of them evaluated only males, six both genders and three did not inform the gender of the subjects. All studies evaluated people over 18 years of age, 68 years was the maximum

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age mentioned, but some did not report. It was mentioned that one of the studies evaluated volunteers over 30 days after the injury and the other up to 25 years after the injury.

Etiology was either reported as traumatic (4), mixed, traumatic and non-traumatic (1) or not informed (5). No study evaluated only people with complete SCI, 5 assessed both people with complete and incomplete SCI, 3 only incomplete injury and 2 did not report it. Considering the entire number of 805 subjects adding the studies included, 323 (40,1%) had cervical injury, 157 (19,5%) thoracic injury, 66 (8,2%) lumbosacral injury and 259 (32,2%) were not informed about the level of injury. Adding the results of 10 studies, 49 volunteers have the ASIA scale, 22B, 106C, 266D and 362 did not inform about the ASIA scale (Table 1).

Manual test (without equipment) was used in 5 studies. Graded and Redefined Assessment of Strength, Sensibility, and Prehension (GRASSP) was used in 3 studies. ASIA - complete protocol was used in 6 studies. ASIA partial protocol was used in 1 study. NRS, WISCI-II, FIM and SCIM-III tests were used in one, three, two and three studies, respectively. Upper limbs were evaluated in 8 studies. Lower limbs were evaluated in 8 studies. Trunk was evaluated in 5 studies, but only through observation, with no specific functional evaluation test (Table 1).

Gait was assessed in half of the studies. Some used robotic technology as a therapeutic resource and pointed out that a better application resulted in the therapies taking place in combination, proving the benefits of reconciling technology in the treatment process.

Both qualitative and quantitative analysis were performed in 8 studies, while 2 performed only quantitative analysis. Regarding the studies that applied the protocol, the time ranged from 4 weeks to 5 months. Assessments were performed before and after protocol application in 2 studies. In 5 studies, assessment occurred before, during and after the application of the protocol. In 2 there was only the evaluation (Table 1).

Gait was assessed in half of the studies. Some studies used robotic technology as a therapeutic resource.

DISCUSSION

The selected articles for this review used one (or more) of the following methods. The manual muscle test (MMT) (Jung et al., 2019, Sørensen & Månum, 2019, Behrman et al., 2012b, Buehner et al., 2012 and Henao-Lema & Pérez-Parra, 2016) is mentioned, but

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only in Buehner et al. (2012) a study with numerical results is presented (functional outcome measures pre- and postintervention for the overall sample). Other studies showed only the ASIA scale. Using the results of the tests performed and relating them to the other tests is important so that it is possible to identify more details about the functionality of patients, especially in more complex cases, such as those with incomplete SCI (Spinal Cord Injury).

A greater number of volunteers with cervical spinal cord injury was observed in the studies analyzed, as follows: people with cervical SCI (323) were evaluated in nine studies; except in Bluvshtein et al. (2011); where they compared two groups; one with trauma SCL and non-trauma SCL. Volunteers with thoracic SCI (157) were mentioned in six studies, and none of them used a manual strength-test protocol specific to the trunk, but other protocols, which are shown in Table 1.

Volunteers with lumbosacral injury represented the smallest number (66). A total of 259 persons with SCI did not inform the injury level, this makes it difficult to understand the evaluation performed, considering that it does not make clear the level of the injury, thus, the reader is not aware of the functional impairment and the relationship with the tests and/or results.

Concerning the ASIA Impairment Scale (AIS), 49 volunteers had grade A, 22 B (both for motor complete injury), 106 C, and 266 D (both for motor incomplete injury), whereas 362 did not inform. The lack of details about the SCI level, whether complete or incomplete, makes it difficult to understand the tests performed, as well as the results achieved in the analyzed studies.

GRASSP is a multimodal tool to evaluate the upper extremities and was used in 3 studies: Jung et al. (2019), Grasse et al. (2019) and Sørensen & Månum (2019). Although not highlighted in Sørensen & Månum (2019), there are differences in the chair back angle and height which allows some voluntary control of the trunk, considering that 3 of those evaluated had complete and one incomplete SCI.

NRS is a step-by-step classification tool that considers the individual's ability to perform specific movements in relation to pre-injury ability, such as standing and walking. Behrman et al. (2012) pointed out that it is a good tool to help monitor movements without compensation, which enables improvements for patients with SCI grade C or D.

WISCI-II is a scale that goes from 0, when the individual cannot walk, to 20 points, when the person can walk independently. The analysis doesn't consider trade-offs or

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segment details (Yildirim et al., 2019). It was used in Yildirim et al. (2019), Soma et al. (2021), and Pérez-Sanpablo et al. (2017). In this way, it is a tool that evaluates gross movements, what makes it necessary to be complemented with more specific functional tests for a more detailed evaluation.

FIM includes thirteen motor and five socio-cognitive measures and was used in Bluvshtein et al. (2011), where they did functional evaluations on admission to rehabilitation and before discharge, and Yildirim et al. (2019), which compared robotic therapy training for 8 weeks and conventional therapy. Jung et al. (2019) investigated the effects of robotic therapy in comparison with conventional therapy to upper limb in patients with cervical SCI. They used the Spinal Cord Independence Measurement III (SCIM-III) to verify the change in the independence index in ADL. Studies that used robotic therapy and conventional therapy demonstrated that the combined application promotes a longer duration of the treatment effectively period according to the combined resource (JUNG et al., 2019).

Considering body segment, the upper limbs were assessed in 8, lower limbs in 7 and trunk in 5 papers, while gait was analyzed in 5 studies. Bluvshtein et al. (2011) and Henao-Lema & Pérez-Parra (2016) presented a qualitative study, while the other studies carried out qualitative and quantitative studies. Functional assessment can take place in isolation or to monitor the outcome of the treatment. In the case of the articles analyzed, in both situations the absence of observation details by segment was noticed.

Bluvshtein et al. (2011) and Henao-Lema & Pérez-Parra (2016) performed only an assessment, while the other studies analyzed performed an assessment (before and after) and application of a protocol. Considering the sum of all the volunteers of the articles selected for this study, 443 (55%) informed ASIA scale A, B, C or D while 362 (45%) didn't. It is important to know and clarify the level of commitment in order to assess the success or failure of the treatment performed. Details can make difference, both in the evaluation and in the evolution along the rehabilitation process.

Differences in the chair back angle and height were not mentioned in any of the 10 studies, although it represents part of the observation that the professional do to indicate if its correct according to functional possibilities.

Evaluation paying attention to compensations was mentioned in one study, despite how important is the deep analysis on possible compensation in addition to the identification of muscle groups and why it happens. where they did functional evaluations

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on admission to rehabilitation and before discharge (YILDIRIM et al., 2019) that compared robotic therapy training for 8 weeks and conventional therapy.

It was noticed that more studies are needed with more depth and details on the tests by segment, especially on trunk functionality in people with different levels of SCI.

Although some studies mentioned gait analysis, no specific pelvis and/or trunk muscles evaluation was mentioned despite how important and related they are gait analysis is important for the functional assessment in people with SCI but understanding the functionality by segment is also important to better interpret possible difficulties and/or compensations.

There are groups interested in investigating the functionality of people with SCI. And it is very important that, more and more, the details are considered. At this point, technological advances combined with conventional techniques and protocols can contribute to the advancement of increasingly detailed investigations.

FINAL CONSIDERATIONS

The articles selected for this review used one (or more) methods to functional evaluation in people with SCI. The sum of volunteers from the 10 studies was 805. Of these, 45% didn't inform the level according to the ASIA scale, which is an international benchmark. Of those who reported, mostly had cervical level injury and volunteers with lumbosacral injury represented the smallest number.

The analyzed studies consisted of tests with few details per segment, without the score and/or ASIA scale, which is very important for the reader to have a better idea of the relationship between functional tests and SCI level, as well as how each segment responds to the proposed treatments.

Another important point is that the studies lack a complete functional assessment, which is essential for the elaboration of protocols for the rehabilitation of the person with spinal cord injury.

Thus, from now, it is suggested that more detailed description of the injuries be presented by segment, whenever possible through conventional tests with and without technological resources: as much as possible, is important that more studies present how technology and professional experience, together, may contribut to a better analysis of the functionality of people with SCI.

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