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Original article

Evaluation of Gait in Patients with Spinal Cord Injury at the International Center for Neurological Restoration

[*Evaluación de la marcha en pacientes lesionados medulares en el Centro Internacional de Restauración Neurológica*]

[*Avaliação da marcha em pacientes com lesão medular no Centro Internacional de Restauração Neurológica*]

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ABSTRACT

Introduction: Spinal cord injury could be considered as any alteration of the spinal cord that can lead to changes in movement, sensitivity, or autonomous functions below the level of the injury. Among the main limitations are gait loss, which, in most cases constitutes the major recovery priority for patients.
Aim: To evaluate the progress of patients with spinal cord injury at the International Center for Neurological Restoration.
Materials and methods: From a total of 60 patients, a sample of 30 patients was selected at random for a study that took place between 2017 and 2019. The individuals met the inclusion criteria, and performed gait actions measured with the gait scale for spinal cord injury, version II. The data collected were processed using SPSS 28.

Results: The results showed statistically significant changes in the sample analyzed by sex, region injured, gait rehabilitation time, and overall status. **Conclusions**: The evaluation of gait showed that the related actions taken at the International Center for Neurological Restoration were effective, and led to significant changes in the patients' gait abilities.

Keywords: Gait, spinal cord injury, injury level, evaluation.

RESUMEN

Introducción: La lesión medular se puede considerar como cualquier alteración sobre la médula espinal que puede producir alteraciones en el movimiento, la sensibilidad o la función autónoma por debajo del nivel de lesión, entre las principales limitaciones se encuentra la perdida de la marcha, la cual en la mayoría de los casos representa la mayor prioridad de recuperación de los pacientes. **Objetivo:** Evaluar la marcha en los pacientes lesionados medulares en el Centro Internacional de Restauración Neurológica. **Materiales y métodos:** Para el estudio se seleccionó una muestra aleatoria de 30 pacientes de una población de 60 pacientes entre los años 2017- 2019, los cuales cumplieron con los criterios de inclusión y realizaron actividades de marcha evaluadas con la escala walking spinal cord injury versión II. Los datos obtenidos fueron procesados con el software estadístico SPSS 28. **Resultados:** Los resultados obtenidos mostraron cambios estadísticamente significativos en la muestra analizada por sexo, por región afectada, por tiempo de rehabilitación de la marcha y de forma general. **Conclusiones:** La evaluación de la marcha arrojo que las actividades de marcha realizadas en el Centro Internacional de restauración neurológica fueron efectivas y produjeron cambios significativos en la marcha de los pacientes.

Palabras clave: Marcha, lesión medular, nivel de lesión, evaluación.

SÍNTESE

Introdução: A lesão medular pode ser considerada como qualquer alteração na medula espinhal que possa produzir alterações no movimento, sensação ou função autonômica abaixo do nível de lesão, entre as principais limitações está a perda da marcha, que na maioria dos casos representa a maior prioridade para a recuperação dos pacientes. **Objetivo**: Avaliar a marcha em pacientes com lesão medular no Centro Internacional de Restauração Neurológica. **Materiais e métodos**: Para o estudo, foi selecionada uma amostra aleatória de 30 pacientes de uma população de 60 pacientes entre 2017 e 2019, que preencheram os critérios de inclusão e realizaram atividades de marcha avaliadas com a escala de lesão medular ambulante versão II. Os dados obtidos foram processados com o software estatístico SPSS 28. **Resultados**: Os resultados obtidos mostraram mudanças estatisticamente significativas na amostra analisada por sexo, por região afetada, por tempo de reabilitação da marcha e em geral.

Conclusões: A avaliação da marcha mostrou que as atividades de marcha realizadas no Centro Internacional de Restauração Neurológica foram eficazes e produziram mudanças significativas na marcha dos pacientes.

Palavras-chave: Marcha, lesão medular, nível de lesão, avaliação

INTRODUCTION

A spinal cord injury is any alteration of the spinal cord that can lead to changes in movement, sensitivity, or autonomous functions below the level of the injury (Staas, Formal, Freedman, Fried, & Schmidt, 1998).

The clinical manifestations of the disease are diverse. The most frequently studied one is the spinal cord injury resulting from traumatism. Spinal cord injury (SCI) is a sudden episode that may entail very serious effects, and represent a medical, economic, and social burden for the patients and society. Therefore, it is necessary to provide the proper treatment to patients, and know the type of injury, epidemiology and psychopathology, as well as the most acute and chronic complications and the social needs of prolonged rehabilitation (Christodoulou *et al.*, 2019; Gedde, Lilleberg, Assmus, Gilhus, & Rekand, 2019; Mandigo, Kaiser, & Angevine, 2011; Taylor *et al.*, 2019; Ullah & Rathore, 2018).

They conducted studies on the incidence and prevalence of the epidemiology of spinal cord injury changes, depending on the characteristics of the population, etiological variety, and the methodology of studies. Previous reviews have not mentioned the occurrence of major changes in recent years.

Most epidemiological studies are retrospective, they focus on the traumatic spinal cord injury and have taken place in developed countries. A recent study of the condition in the American population (328 million) showed that the annual incidence of spinal cord injury (SCI) is approximately 54 cases per a million (17.730 new cases every year), according to the National Spinal Cord Injury Statistical Center (2021).

Among the most common limitations caused by spinal cord injury are changes in walking, so its rehabilitation is one of the major patients' priorities (Alashram, Annino, & Padua, 2021; Tan *et al.*, 2021).

Traditionally, the gait rehabilitating re-education programs have included the training and adjustment of remaining able motor parts, the use of supralesional musculature, and the replacement or implementation of the load and impulse device through several different types of orthosis and technical aids (Abou, Malala, Yarnot, Alluri, & Rice, 2020; Aguirre, Perez, Quinzanos, Perez, & Barrera, 2019). Thus, the goal is to design and implement strategies that compensate the limitations (Atrice, Morrison, & McDowell, 2005; Behrman & Hakerma, 2007; Fulk, Schimtz, & Behrman, 2007).

Gait training due to spinal cord injuries adapts to the existing residual musculature, so the type of walking to assume and the technical aids for walking (walkers or Canadian walking sticks), depend on the strength of various muscle groups.

The work of physical rehabilitation emphasized on restoring the essential determinants of walking, which mean maintaining or widening the joint amplitude, developing muscles, normalizing muscle tone, and re-establish coordination and balance. Along with the gait determinants, other strategies for compensation are developed, which enable movements in accordance with the limitations (Alajam, Alqahtanti, Frederick, & Liu, 2020; Barati, Kamyab, & Kamali, 2020; Saha, 2020).

At the International Center for Neurological Restoration, the multidisciplinary team led by a neurologist has designed a working strategy based on an intensive multifaceted system consisting of 2 daily sessions, Monday through Friday, and 1 Saturday session with actions and mobilizations of joints below the injury level, together with exercises to develop muscles above the injured area, and stimulation of the musculature that might have a potential recovery. These actions are conducted alongside others to inhibit or enable proper muscle tone. Upon the team's conclusion that the patient is physically and mentally ready, the gait procedures are performed.

Depending on the level and characteristics of every patient based on their functional forecast for walking, the proper orthosis is prescribed, starting with the trunk balance on two feet, with loads, and finally, body movement.

Due to the importance of gait rehabilitation for the patients' prompt recovery, the influence of the programs or protocols should be reviewed. At the International Center for Neurological Restoration, the patients with spinal cord injury are part of a comprehensive and intensive multifactorial and multidisciplinary rehabilitation program that comprises 6 hours of physical rehabilitation to accomplish functional walking. However, the work is performed according to a program with methodological indications. The evaluation of gait with specific scales depending on the patient has not been duly detailed in previous studies. Hence, the aim of this paper is to evaluate gait in the patients with spinal cord injury at the International Center for Neurological Restoration.

MATERIALS AND METHODS

A methodological design was created with the following characteristics:

Type of study: descriptive. Depending on the time of occurrence and the data records, it may have a retrospective character.

Sample population: A random sample of 30 patients with spinal cord injury, at the International Center for Neurological Restoration was selected from a total of 60 patients in the 2017-2019 period.

Inclusion criterion:

- Patients with T1 and L12 spinal cord injuries.
- Patients who performed the gait training.
- Patients with a 2-3-month rehabilitation time (Table 1, Table 2, Table 2, and Table 4).

Sample distribution

Table 1 *- Distribution by sex*

	Frequency	Percentage
Females	13	43.3
Males	17	56.7
Total	30	100.0

Table 2 - *Distribution based on spinal cord injury time*

	Frequency	Percentage
1	4	13.3
2	8	26.7
3	7	23.3
4	6	20.0
5	3	10.0
6	2	6.7
Total	30	100.0

Table 3 *- Distribution by area affected*

	Frequency	Percentage
Back	18	60.0
Lumbar	12	40.0
Total	30	100.0

Table 4 - *Distribution as to time used for gait rehabilitation*

	Frequency	Percentage
2 months	17	56.7
3 months	13	43.3
Total	30	100.0

Study methodology

After the selection of the study sample, the rehabilitation documents were reviewed (rehabilitation records), with the general data and gait evaluation, according to the gait index for spinal cord injury version II, at the beginning and end of the rehabilitation period. The data were processed using SPSS 28, for descriptive statistics and to conduct the corresponding inference analysis through the Wilcoxon test to determine if the changes observed in the patients were statistically significant.

Gait training was conventional.

Gait index for spinal cord injury (WISCI II), Descriptors (Ditunno-Jr et al., *2013)*

The physical limitation to walk derived from a disability is defined on a person-to-person level, and it indicates the disability of a person to walk following a spinal cord injury. The development of this index required an order of classification in the dimension of disability, from the most serious (0) to the least serious (20), depending on the utilization of devices, orthopedic aids, and physical assistance by one or more individuals. The level arrangement suggests that every successive level is less deteriorated than the previous. The classification of seriousness is based on the deficiency (or not) of surrounding functional independence. The following definitions standardize the terms used on each item:

- Physical assistance: The assistance of two individuals is moderate-maximum.
- The one-person assistance is minimum-moderate.
- Minimum contact is the lowest assistance level.
- Orthopedic devices: It means one or two devices, either for short or long legs.
- A splint on the lower limbs is considered an orthopedic device for long legs.
- No orthopedic device means that there are no devices on any leg.
- Walker: It is a one-piece walker without wheels.
- Crutches: They may be Lofstrand (Canadian) or axillary.
- Walking stick: A straight conventional stick.

Level description

1. Unable to stand and/or take up assisted gait.
2. Wandering (less than 10 m) on parallel bars, with a device on and physical assistance from two persons.
3. Wandering (10 m) on parallel bars, with a device on and physical assistance from two persons.
4. Wandering (10 m) on parallel bars, with a device on and physical assistance from one person.
5. Wandering (10 m) on parallel bars, without a device on and physical assistance from one person.
6. Wandering (10 m) on parallel bars, without a device on and no physical assistance.
7. Wandering (10 m) using a walker, with a device on and physical assistance from one person.

8. Wandering (10 m) using two crutches, with a device on, and physical assistance from one person.
9. Wandering (10 m) using a walker, without a device on, and physical assistance from one person.
10. Wandering (10 m) using a walker, with a device on, and no physical assistance.
11. Wandering (10 m) using a walking stick/crutch, with a device on, and physical assistance from one person.
12. Wandering (10 m) using two crutches, without a device on, and physical assistance from one person.
13. Wandering (10 m) using two crutches, with a device on, and no physical assistance.
14. Wandering (10 m) using a walker, without a device on, and no physical assistance.
15. Wandering (10 m) using a walking stick/crutch, with a device on and physical assistance from one person.
16. Wandering (10 m) using a stick/crutch, with a device on, and no physical assistance.
17. Wandering (10 m) using two crutches, without a device on, and no physical assistance.
18. Wandering (10 m) without aid or device on, and physical assistance from one person.
19. Wandering (10 m) without aid, with a device on, and no physical assistance.
20. Wandering (10 m) using a stick/crutch, without a device on, and no physical assistance.
21. Wandering (10 m) without aid or a device on, and no physical assistance.

RESULTS

To determine the gait evolution of patients upon rehabilitation, several evaluations were conducted, depending on the sex, affected area, treatment time, and overall state. It was on the null hypothesis and the determination if the treatment was appropriate to produce the significant changes expected in the gait ability.

Hypothesis

- H_0= No changes in the gait index for spinal cord injury at the beginning and end.
- H_1= There are changes in the gait index for spinal cord injury at the beginning and end.

Significance level

The Wilcoxon rank sum test was used to set the significance levels (alpha) $\alpha = 5\% = 0.05$ %

Table 5 - *Wilcoxon rank sum test[a] by sex*

	Sex			
	Females		Males	
	Z	**Sig. Asymptotic (two-sided)**	**Z**	**Sig. Asymptotic (two-sided)**
Gait index for spinal cord injury end - Gait index for spinal cord injury beginning	-3.189[b]	.001	-3.636[b]	**.000**

a. Wilcoxon rank sum test
b. Based on negative ranks.

Table 5 shows the results of the Wilcoxon rank sum test of the sample, according to sex, in which the patients were observed to have positive results before and after the treatment when the gait scale was used (Table 5).

Table 6. - *Wilcoxon[a] rank sum test by area affected*

	Area affected			
	Back		Lumbar	
	Z	**Sig. Asymptotic (two-sided)**	**Z**	**Sig. Asymptotic (two-sided)**
Gait index for spinal cord injury end - Gait index for spinal cord injury beginning	-3.764[b]	.000	-3.071[b]	**.002**

a. Wilcoxon rank sum test
b. Based on negative ranks.

Table 6 shows the results of Wilcoxon rank sum test of the sample according to the area affected, in which the patients with back and lumbar injuries showed significant results before and after the treatment, upon the application of the scale (Table 6).

Table 7.- *Wilcoxon[a] rank sum test by rehabilitation time*

	Time spent during gait rehabilitation			
	2 months		3 months	
	Z	Sig. Asymptotic (two-sided)	Z	Sig. Asymptotic (two-sided)
Gait index for spinal cord injury end - Gait index for spinal cord injury beginning	-3.642[b]	.000	-3.184[b]	.001

a. Wilcoxon rank sum test.
b. Based on negative ranks.

Table 7 shows the results of Wilcoxon rank sum test of the sample according to the time spent on rehabilitation. The patients showed significant results before and after the treatment, with rehabilitation time of 2-3 months, based on the gait scale (Table 7).

Table 8. *- Wilcoxon[a] rank sum test of the sample as a whole*

	Z	Sig. Asymptotic (two-sided)
Gait index for spinal cord injury final - Gait index for spinal cord injury beginning	-4.798[b]	.000

a. Wilcoxon rank sum test.
b. Based on negative ranks.

Table 8 shows the results of the Wilcoxon rank sum test of the overall sample, in which the patients were observed to have positive results before and after the treatment when the gait scale was used (Table 8).

DISCUSSION

The data analysis revealed significant results in every aspect, though this outcome should not lead to general inferences based on the observations; instead, a more objective standpoint is required to contextualize this research.

The analysis by sex and area affected coincided with (Benito-Penalva *et al.,* 2012), who noted that a positive response associated with training is not to be affected by the etiology of the injury, age, sex, or injury level. It differed from the findings of a team of researchers (Richard-Denis, Benazet, Thompson, & Mac-Thiong, 2020), who determined the priorities of functional rehabilitation, and that in terms of mobility, women responded better than men.

As to the rehabilitation time spent, the sample only revealed positive results for patients with two and three months of training, coinciding with a study on gait training using a robot, in which the significant changes were observed between five weeks and three months (Midik, Paker, Bugdayci, & Midik, 2020). Other studies referred to robot-assisted training, or the utilization of a powered exoskeleton (Kanazawa, Yoshikawa, Koseki, Takeuchi, & Mutsuzaki, 2019; Wu *et al.,* 2018), but the conventional gait training showed higher results.

Most current studies on gait rehabilitation of the spinal cord injured patients are based on the utilization of new technologies (Manns, Hurd, & Yang, 2019; Okawara *et al.,* 2020; Stampacchia *et al.,* 2020), though it is also important to conduct studies on the conventional methods due to the cost of new technologies, which are unavailable to many.

CONCLUSIONS

The results observed in this research study show that the patients with spinal cord injuries on their backs or lumbar areas, who perform gait training at the International Center for Neurological Restoration for 2-3 months will have a high chance of improving their gait ability significantly, regardless of the sex or injury degree.

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Author contribution statement:
Alexander Echemendía del Valle: Conceptualization, data curation, data analysis.

Reinaldo Gómez Pérez: Data curation.

Armando Sentmanat Belisón: Methodology, critical review of the manuscript.

Bárbara Yumila Noa Pelier: Critical review of the manuscript.