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**Case Report**

# Effect of an intervention protocol based on motor learning for walking and balance in young patient with primary lateral sclerosis: a case study

## *Efeito de um protocolo de intervenção baseado na aprendizagem motora para marcha e equilíbrio em jovem com esclerose lateral primária: um estudo de caso*

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**ABSTRACT:** *Introduction:* Primary lateral sclerosis (PLS) is a rare disease characterized by the upper motor neuron degeneration that usually begin in the sixth decade of life. It has an insidious onset of symmetrical, slowly progressive spastic paresis, which often initially affects upper and lower limbs. The practice of exercises may benefit people with PLS by motor learning and improving their poor motor repertoire. *Objective:* To determine the effect of a motor learning-based intervention protocol to improve walking and balance in a young woman with PLS. *Methodology:* This is a case report of PLS in a 29-year-old Caucasian female, single, Colombian, submitted to pre-test evaluation (1 session), motor learning-based protocol intervention (18 sessions) and post-test evaluation (1 session). For data collection, the Tinetti Scale, Romberg test, Timed Get Up And Go, Functional Range test, Baropodometry and Stabilometry were used. *Results:* The Tinetti Scale (postural reaction) showed improvement in a foot swing; in the Tinetti Scale (walking) the positive results were found in width, symmetry, continuity and direction of the walk; Romberg Tests showed evolution for stability on flat surfaces with closed eyes and on Fomy foam with open eyes; in the Timed Get Up & Go Test the travel time was reduced from 13.64 seconds to 12.5 seconds. *Conclusion:* After the application of the protocol of intervention based on motor learning there were functional advances in gait and balance of young with ELP.

**Keywords:** Learning; Gait; Postural balance; Lateral sclerosis.

**RESUMO:** *Introdução:* A esclerose lateral primária (ELP) é uma doença rara caracterizada por uma degeneração do neurônio motor superior ocorrendo geralmente na sexta década de vida com um início insidioso de uma paresia espástica simétrica, lentamente progressiva, frequentemente começando em membros superiores e inferiores. A prática de exercícios pode trazer benefícios a estes sujeitos levando a uma aprendizagem motora e melhorando o repertório motor insuficiente. *Objetivo:* Determinar o efeito de um protocolo de intervenção baseado na aprendizagem motora para melhorar a marcha e equilíbrio em jovem com ELP. *Metodologia:* É um estudo de caso composto por uma mulher, 29 anos, solteira, colombiana, branca, submetida à avaliação pré-teste (1 sessão), intervenção de protocolo (18 sessões) e pós teste (1 sessão). Para coleta de dados foram utilizados a Escala de Tinetti, Teste de Romberg, *Timed Get Up And Go*, Teste de alcance funcional, Baropodometria e Estabilometria. *Resultados:* A Escala de Tinetti (reação postural) mostrou melhora para balaço em um pé; na Escala de Tinetti (marcha) os resultados positivos foram encontrados em largura, simetria, continuidade e direção do passo; Testes de Romberg mostraram evolução para estabilidade sobre superfície plana com olhos fechados e sobre espuma de Fomy com olhos abertos; no teste *Timed Get Up & Go* o tempo de percurso foi reduzido de 13,64 segundos para 12,5 segundos. *Conclusão:* Após a aplicação do protocolo de intervenção baseado na aprendizagem motora houve avanços funcionais em marcha e equilíbrio de jovem com ELP.

**Palavras-chave:** Aprendizagem; Marcha. Equilíbrio postural. Esclerose lateral.

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## INTRODUCTION

Primary lateral sclerosis (PLS) is a rare disease characterized by the upper motor neuron degeneration that usually begin in the sixth decade of life. It has an insidious onset of symmetrical, slowly progressive spastic paresis, which often initially affects upper and lower limbs. Compared with amyotrophic lateral sclerosis (ALS), PLS has a slower progression rate and a survival prognosis of more than 10 years from the onset of symptoms[1-4]. Studies estimate that approximately 2% to 5% of patients of adult neuromuscular clinics are PLA[2], with a higher male prevalence[2] and may present symptoms such as spasticity, hyperreflexia, hypertonia, joint stiffness, muscle weakness, cognitive, coordination and balance deficits[5].

As the symptoms progress, functional independence suffers a decline and may incapacitate the individual in performing activities of daily living (ADLs)[6]. Exercises can bring benefits leading to motor learning and improving the insufficient motor repertoire. Motor learning is described as a relatively permanent change, resulting from experience and practice, in the individual's ability to perform a certain motor skill[7].

A detailed assessment is necessary to identify the barriers and facilitators in the rehabilitation process, however, there is a shortage of work in the literature that address the physical therapy performance in PLS, mainly based on the principles of motor learning. Therefore, the need arose to carry out this study by conducting tests at the Human Movement Laboratory of the *Universidad Autónoma de Manizales* (UAM), Colombia, to determine the effect of an intervention protocol based on motor learning to improve gait and balance in young people with PLS. The availability of a protocol based on the foundations of motor learning aimed at individuals with PLA may benefit not only patients with this diagnosis, but also physiotherapists who work in neurorehabilitation.

## MATERIALS AND METHODS

### *Subject*

The research is experimental, a case report type, composed by a 29 years old woman, single, Colombian, white, administrative assistant, belonging to the contributory social security regime (Colombian health system). She was admitted to the IPS UAM Foundation Service on July 13, 2015 with a diagnosis of extrapyramidal and movement disorder, presenting hamstring spasticity, generalized muscle weakness, slow gait with short steps and reduced range of motion in dorsiflexion and plantar flexion, causing several stumbles. She underwent physiotherapy during 2015 with neuromotor improvements, however, she needed to end the treatment due to the limitation of her health service. On April 6, 2017, she returned to the service with a new diagnosis of PLS, still presenting spasticity in the lower limbs, bilateral thightness of the plantar flexors and alteration of the normal gait pattern. This study was approved by the Bioethics Committee No. 080-2018 of the *Universidad Autónoma de Manizale*s (UAM). The patient signed the Free and Informed Consent Form (FICF) authorizing her voluntary participation in the study.

### *Mesuarements instruments*

Tinetti scale[8] for the assessment of postural reaction and stability during ambulation. This is a scale that simultaneously assesses gait and balance, these two aspects provide information on the risk of falls and determine whether there are changes that require intervention. It comprises nine items of balance and seven of march. Responses can vary between 0, 1 and 2 for abnormal, compensated, and normal executions, respectively. The maximum balance score is 16 and that of gait 12, the sum of both being less than 19 is indicative of a high risk of falls.

Romberg's test[9] modified with eyes closed and open, on a flat surface and on foam to assess the sensory organization, with each condition scored between 0, referring to incapacitated, and 3, referring to stable. The original test is focused on investigating the imbalance and difficulty in walking with the patient in a bipedal position with eyes closed. The positive result of this test indicates damage to the proprioceptive pathway.

Gait speed assessed according to the timed time the subject uses, as well as the number of steps, to walk 6 meters in a straight line.

*Timed Get Up And Go*[10,11] assesses the risk of falls, whose performance is related to gait, balance and functional capacity. It is considered normal when the travel time is less than 10 seconds to get up from a chair without forearm supports, walk 3 meters in a straight line, turn, walk back to the starting point and sit down again.

Functional reach test[12] considers the patient in an orthostatic position, barefoot, with the spine erect, looking fixedly at the horizon, with upper limbs in shoulder flexion at 90º and right hemibody close to the wall. The subject is asked to stretch as much as he can, keeping his feet fixed on the ground, flexing his torso and respecting the same original position as his upper limbs; from this, the distance covered in centimeters reached by the individual's hands is verified.

Baropodometry and stabilometry[13] are complementary and objective tests that record plantar pressures and static stability on a P6000 force platform and two pressure or baropodometric P-walk platforms composed of sensors. Six Dx 6000 optoelectronic cameras, two digital video cameras and a FREEEMG100 eight-channel wireless electromyograph were also used.

### *Procedures*

The protocol used was based on the principles of motor learning to improve the gait and balance of patients with PLS (Chart 1). The protocol was applied at the IPS UAM Foundation Service, for six weeks (August 9, 2018 to September 20, 2018), with three weekly sessions on alternate days, lasting 50 minutes each session. The patient was initially evaluated for treatment on June 21, 2018 and at the end, on September 28, 2018.

**Chart 1 –** Protocol based on motor learning principles to improve PLS patient`s gait and balance

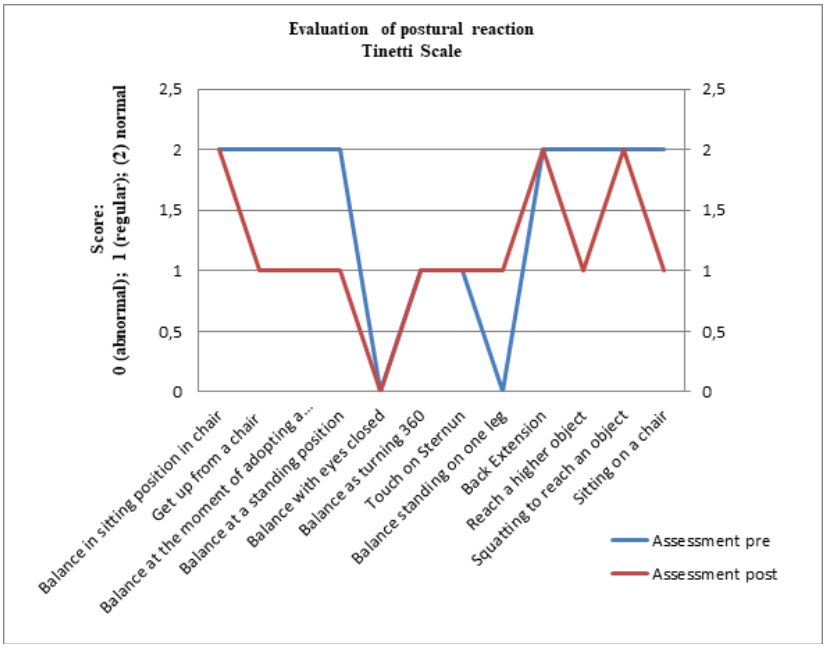
| **WEEKS** | **WEEK 1** | **WEEK 2** |
|---|---|---|
| **Activities** | 1. Sit up and get up*<br>2. Keep orthostatic position for 30 seconds with eyes opened**<br>3. Keep orthostatic position for 30 seconds with eyes closed**<br>4. Execute static walk**** | 1. Walk forward a 5 meter course without obstacles *<br>2. Walk sideways a 5 meters course without obstacles ** |
| **Recommendations** | * Use a chair without a forearm support. Start the task seated, with your hands resting on your thighs and feet aligned and resting on the floor. Get up from the chair using the strength of your legs and, if necessary, also use the strength of your hands to project forward and upward. After getting up, wait for about 2 seconds and sit in the chair. Perform this task (sit and stand) a few times until it is finished in one minute or, before 1 minute, if you reach your fatigue limit.<br><br>** Standing (orthostatism) look for a fixed point in front of you and take it as a reference to keep your chin in a horizontal line. Try to stand in an upright position with good body posture, arms hanging down and lying on your sides for 30 seconds. If you cannot complete the time, sit down, rest and try again. If it is very difficult to keep time on the first day, do the task for 15 seconds and try the 30 seconds again.<br><br>*** The task follows the same guidelines as the previous task with the difference that you must now keep your eyes closed.<br><br>**** Get up and make movements with your legs as if you were going to walk without moving, raising your knees very high. Your hands should be supported on your waist. Complete the task in 30 seconds.<br><br>PS: Her goa lis to finish the task, there is no need of sets or repetitioons. | * Choose a location that has enough room and has a flat surface. Ask someone to help you check the images of the space using a tape measure or mat and mark the beginning and end of a 5-meter walk straight on the floor (with tape). It is in this area that you must walk at the speed you usually walk, as naturally as possible and without support. Do the task in the best possible way and at the normal pace.<br><br>** This task is based on the previous recommendations. The only adaptation is that you must do the tour walking sideways. Use the 1 minute rest time between the two tasks.<br><br>PS: For both tasks, it is recommended that you perform them a few times until the 5 minute time is reached. At this time, make the round trips you consider necessary to complete the time. Do not accelerate your steps to do several walks in these 5 minutes, the objective of the exercise is not how many times you will be able to do it, but rather to train your gait to execute it with the highest quality you can. |
| **Weeks** | **Week 3** | **Week 4** |
| **Activitiess** | 1. Walk forward a 5 meter course with obstacles*<br>2. Walk sideways a 5 meters course with obstacles** | 1. Walk forward a 10 meter course with obstacles*<br>2. Walk sideways a 10 meters course with obstacles** |
| **Recommendations** | *, ** To go through an obstacle course, you can use cones, canes or small boxes on the floor with space between them that allows you to take a free step, overcoming heights (raise your leg high to avoid tripping). Use the recommendations given for the previous week. The goal is to encourage ever higher steps and more distant steps. | *, ** Follow the same recommendations as the previous week, but now you must establish a longer travel space (10 meters). |
| **Weeks** | **Week 5** | **Week 6** |
| **Atividades** | 1. Walk forward a 10-meter course, with obstacles and an object in your hands *<br>2. Walk sideways for 10 meters, with obstacles and with an object in your hands ** | 1. Walk forward a 10-meter course, with obstacles and an object in your hands *<br>2. Walk sideways for 10 meters, with obstacles and with an object in your hands ** |
| **Recomendações** | *, ** Repeat the same information from the previous week, however, now you must perform the tasks holding a ball with both hands, placed in front of your body (shoulder flexion at approximately 90º, total elbow extension, neutral wrists). | *, ** Repeat the same recommendations as the previous week. |

Source: Silva Filho et al., 2018.

## RESULTS

According to the Tinetti Scale (postural reaction), the patient obtained 18 points before treatment and 14 after, over a total of 24 points, which shows an altered pattern of static and dynamic balance even after the intervention, showing improvements for balance on one foot and worsening to get up from the chair, sway when positioning and standing, reaching a tall object and sitting on a chair (Graph 1).

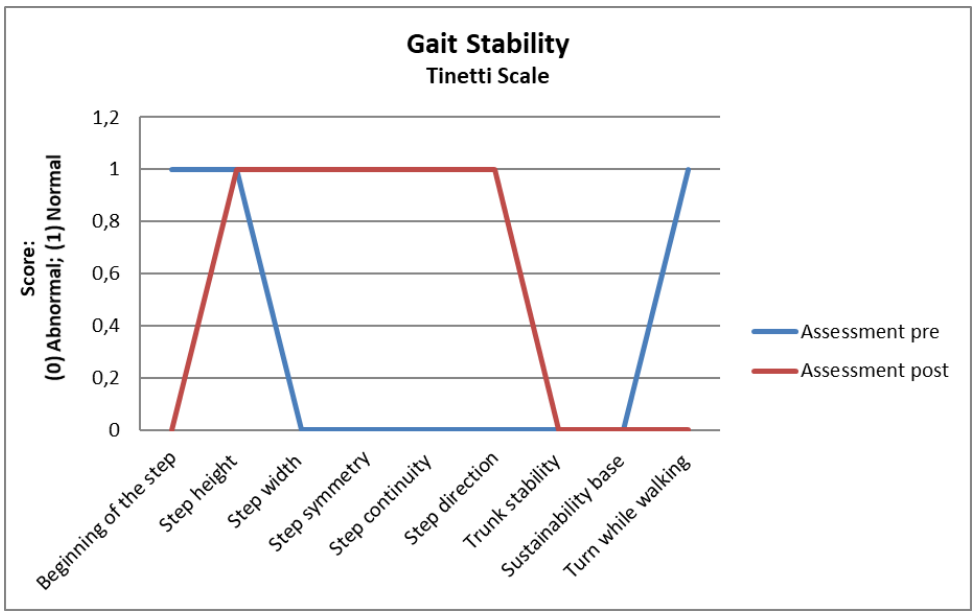
**Graph 1** – Postural Reaction pre and post assessments (Tinetti Scale)




**Source**: *Laboratorio Análisis de Movimiento – Universidad Autónoma de Manizales.*

The Tinetti Scale (gait) presented three and five points, pre and post-test, respectively, on a total of nine, with positive results in width, symmetry, continuity, and direction of the step and negative in turning while walking and beginning of the step (Graph 2).

**Graph 2** – Gait stability pre and post assessments (Tinetti Scale)



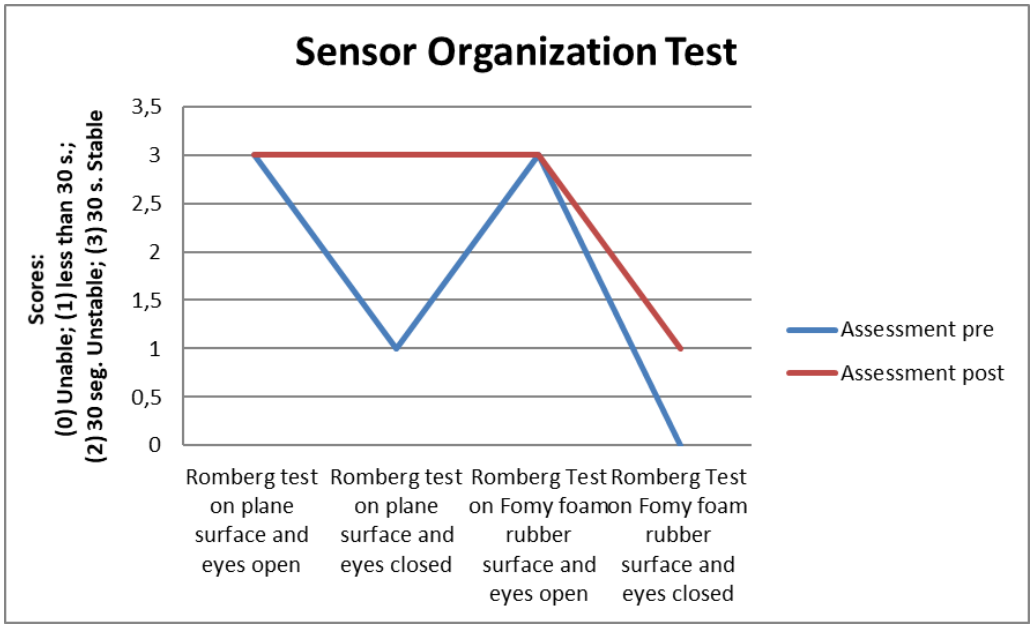

**Source**: *Laboratorio Análisis de Movimiento – Universidad Autónoma de Manizales.*

The user was stable in the Romberg Tests with eyes open on a flat surface and on Fomy foam, before and after the intervention. On a flat surface with closed eyes, she showed evolution, passing from less than 30 seconds in the standing position (pre-test) to more than 30 seconds: stable (post-test). The improvement was also evident on Fomy foam with eyes open after treatment, passing from unable to perform to remain stable for less than 30 seconds (Graph 3).

There were no improvements in gait speed in the number of steps to cover six meters, 16 in the pre-test and 14 in the post-test, as well as in the time to cover 6 m: 6.9 sec and 8.5 sec in the pre and post-test, respectively. However, there was a reduction in travel time in the Timed Get Up & Go test; 13.64 sec and 12.5 sec, pre and post-test, respectively. The Functional Range Test showed no improvement, as there was a reduction in the distance covered: 38.85 cm (pre-test); 34.25 cm (post-test).

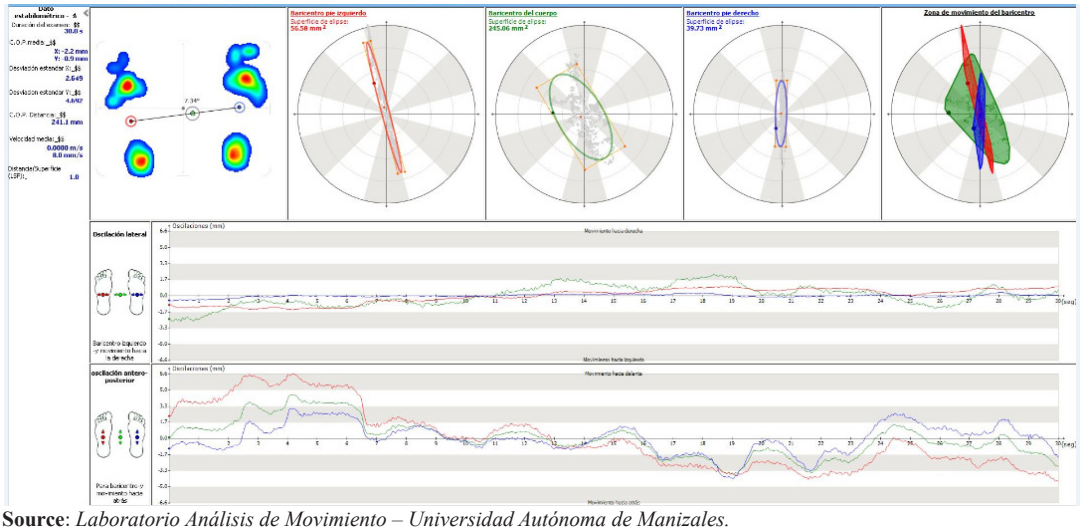
According to baropodometry, in the pre-test, a strong pressure was observed in the left foot, more precisely in the region of 2nd and 3rd metatarsals and medial heel face. In the post-test, it was noted that the left foot was still under greater pressure, however in the 4th and 5th metatarsals.

**Graph 3** – Sensory Organization Test pre and post assessments (Romberg)



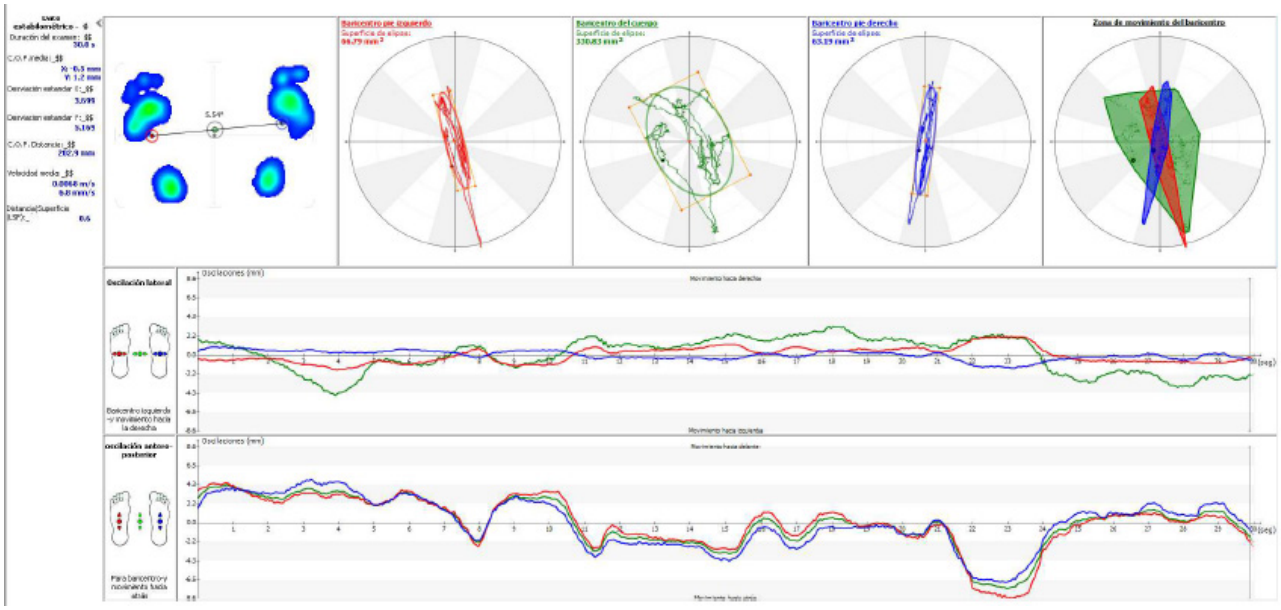

**Source**: *Laboratorio Análisis de Movimiento – Universidad Autónoma de Manizales.*

On the Stabilometry, the results were obtained with the user with eyes open, because with eyes closed it was not possible to perform. It was observed that the latero-medial oscillations were more evident than the antero-posterior ones, in the pre-test and in the post-test, however, in the latter the oscillations were smaller (Figures 1 and 2).



**Source**: *Laboratorio Análisis de Movimiento – Universidad Autónoma de Manizales.*

**Figure 1** – Stabilometry results pre-test



**Source:** *Laboratorio Análisis de Movimiento – Universidad Autónoma de Manizales*.

**Figure 2** – Stabilometry results post-test

## DISCUSSION

After applying the protocol during physical therapy, the patient improved in some aspects of walking. The balance also showed progress on a stable surface with eyes closed, as well as on an unstable surface with eyes open. An analysis of how motor learning can be optimized in adults may have important theoretical and practical implications. Baropodometry can contribute to the functional diagnosis given by physiotherapists and stabilometry has the ability to quantitatively measure the variables associated with balance and can offer validity to clinical tests. In this research, the patient showed minor oscillations in post-workout balance compared to pre-workout. These results corroborate with other researchers who investigated individuals with Charcot-Marie-Tooth disease and showed, through stabilometry, a difference in muscle strength in all ankle movements, which leads to greater balance instability[14]. Another study carried out with a neurological patient collected data on oscillations and pressure, pre-training and post-training, in orthostatism, with baropodometry and stabilometry and the results showed an improvement in the lateral-medial and anteroposterior displacement, increasing the control of the trunk and decreasing the chance of falls[15].

Walking promotes independence during ADL's and its analysis is important to understand the variables present in locomotion, basing the treatment of diseases that compromise the locomotor system. During deambulation, deficit in balance and proprioception are pointed out as important causes of falls in neurological patients, therefore, there is a need to develop physiotherapeutic interventions that effectively improve these problems[16]. The post-test showed advances in the aspects evaluated. Little is known about the effect of the practice on subjects with ALS and nothing has been found with PLS, however, research has been developed on gait and balance training aimed at other demyelinating diseases, which may agree with our findings.

A case report investigated the effects of physiotherapy on gait, balance, flexibility and muscle tone in a patient with multiple sclerosis and obtained positive results after treatment[17]. A study evaluated motor changes in a patient after Guillain-Barré syndrome and found that the physiotherapeutic techniques used were effective in the rehabilitation process and led to improvements in muscle strength, range of motion, gait and balance[18]. Almeida et al.[19] assessed the balance of nine individuals with Parkinson's disease before and after a physical therapy program and suggested improvement among the subjects evaluated. In the research by Marcon et al.[20] changes in balance through virtual reality, pre and post intervention, and their influence on quality of life in five individuals with MS were studied and the results showed that training leads to the restoration of balance and makes it possible to influence in quality of life in multiple sclerosis. Two patients with Steinert's Muscular Dystrophy were separated, one control only with conventional physiotherapy and the other with physiotherapy and Wii rehabilitation practice, assessed through baropodometry and the results showed that the practice led to improved balance[21].

It is observed in the literature that physical rehabilitation based on practice and repetition (necessary for there to be motor learning) in neurological patients, generally offers good treatment effectiveness, allowing the use of this protocol to be promising in PLS.

## CONCLUSION

The creation and application of the intervention protocol based on motor learning led to functional advances in gait and balance of young people with PLS. This is a rare and progressive disease, and the therapeutic approach should start immediately for a better prognosis. Although it was developed according to the functional framework of a specific patient, the protocol can be useful as a basis for consultation for the preparation of other proposals with similar objectives.

### Study limitations

Despite the positive results, a case study does not allow generalizing recommendations. Clinical trials involving larger samples could demonstrate the benefits of this protocol and indicate good levels of statistical significance.

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**Authors participation:** *Silva Filho JA, Bernal MYP, Ruiz JC*: Data collection pre-test. *Silva Filho JA*: Elaboration of Intervention Protocol. *García CIG*: Application of intervention Protocol. Bernal MYP; Ruiz JC: Data collection post-test. *Silva Filho JA*: Research and literature analysis. *Silva Filho JA*: Reading and writing the text. *Bernal MYP, Ruiz JC*: Organizational orientation. Bernal MYP; Ruiz JC: Text review regarding vracity and integrit of references used. *Silva Filho JA*: Final review and paper submition.

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