ORIGINAL ARTICLE

Combined effects of physiotherapy and robotic therapy on gait balance and speed in patients with incomplete spinal cord injury

Efeitos combinados da fisioterapia e terapia robótica no equilíbrio e velocidade da marcha em pacientes com lesão medular incompleta

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ABSTRACT

Restoring the ability to walk, especially independently, is one of the goals in the rehabilitation of patients with incomplete spinal cord injury (ISCI). Thus, task-oriented gait training takes into account the fundamental principles of motor learning, involving mechanisms of central neuroplasticity and consequently cortical reorganization. The G-EO System (GS) robotic gait training acts as a reinforcer of the repetitive and specific practice of the gait phases. **Objective:** To investigate the combined effects of physiotherapy and robotic therapy on gait functionality in relation to balance and gait speed in patients with ISCI. **Methods:** Retrospective cohort study with 14 patients in the chronic phase of the disease, using the GS as a robotic intervention for gait and stairs, consisting of a 20-session protocol associated with conventional physical therapy. We used the 10-meter Walk Test (10WT) and the Berg Balance Scale (BBS). P values <0.05 were considered statistically significant using the Wilcoxon test at the beginning of conventional physical therapy and before and after intervention. **Results:** Significant differences between the scales were observed. At the 10WT, the mean initial velocity ranged from 2.60 m/s ± 1.72 at the beginning of conventional physical therapy to 1.57 m/s ± 0.80 at the end of the 20 GS sessions with p = 0.0424. For BBS at the beginning of conventional physical therapy, the average was 31.85 points ± 12.50, and 42.35 ± 14.25 at the end of the 20 GS sessions, with p = 0.0096. **Conclusions:** Robotic gait therapy associated with conventional physiotherapy has been shown to be effective in promoting balance and gait speed improvement in individuals in the chronic phase after involvement of incomplete spinal cord injury.

Keywords: Spinal Cord Injury, Gait, Balance, Physical Medicine and Rehabilitation, Neurological Rehabilitation, Robotic

RESUMO

Restaurar a capacidade de andar é um dos objetivos da reabilitação na lesão medular incompleta (LMI). O treino orientado a tarefa abrange os princípios do aprendizado motor, envolvendo mecanismos de neuroplasticidade central e, consequentemente, reorganização cortical. O treinamento da marcha robótica G-EO System (GS) atua como um reforço da prática repetitiva e específica das fases da marcha. **Objetivo:** Investigar os efeitos combinados da fisioterapia e da terapia robótica na funcionalidade da marcha em relação ao equilíbrio e velocidade da marcha em pacientes com LMI. **Métodos:** Estudo de coorte retrospectivo com 14 pacientes na fase crônica da doença, que realizaram 20 sessões de GS associado à fisioterapia convencional (FC). Utilizamos o Teste de Caminhada de 10 Metros (TC10) e a Escala de Equilíbrio de Berg (EEB). Valores de p <0,05 foram considerados estatisticamente significativos pelo teste de Wilcoxon ao início da fisioterapia convencional e pré e pós intervenção. **Resultados:** Observou-se que no TC10, a velocidade inicial média variou de 2,60 m/s ± 1,72 no início da FC a 1,57 m/s ± 0,80 no final das 20 sessões de GS com p = 0,0424. Para a EEB no início da FC, a média foi de 31,85 pontos ± 12,50 e 42,35 ± 14,25 ao final da intervenção, com p = 0,0096. **Conclusão:** A terapia robótica da marcha associada à FC mostrou-se eficaz na promoção do equilíbrio e da melhora da velocidade da marcha em indivíduos na fase crônica da LMI.

Palavras-chave: Traumatismos da Medula Espinal, Marcha, Equilíbrio, Medicina Física e Reabilitação, Reabilitação Neurológica, Robótica

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INTRODUCTION

Restoring and regaining the ability to walk, especially independently, is one of the goals in the rehabilitation of patients with ISCI, due to its great impact on the individual's quality of life, independence and participation in society. Thus, task-oriented gait training[1] takes into account the fundamental principles of motor learning,[2] involving mechanisms of central neuroplasticity[3] and consequently cortical reorganization.[4,5]

From this, robotic gait training allows for repetitive practice and specific to the gait phases,[6,7] knowing that the practice of all phases is necessary for the complete accomplishment of the gait cycle,[8] we use the GS as reinforcer for the occurrence of this process.

It is worth remembering that robotic therapy saves the physiotherapist's effort to assist the individual during training, also offering greater security regarding the risk of falls due to gait impairment,[9] because the GS is seen as a robotic gait rehabilitation device, aimed at for individuals who have a change in lower extremity motor function.[10]

Thus, the GS is regarded as a modern robotic gait rehabilitation device[10] based on the modular platform concept from the offer of different modules and therapeutic options,[11] such as motion segmentation, gait and stair simulation and switching between modes. passive, active-assisted and active.[10]

Among the adjustable and controllable parameters that allow treatment effectiveness are: step length and width, gait cadence and speed, ankle angle, step height, dynamic weight support body mass movement, center of body mass movement and horizontal activation of the hips, as well as the detection of the individual's weight loss through the platforms,[10] providing detailed reports that allow the assessment of the individual's progress and the progression of the behaviors with the individual.[11]

GS-powered robotic therapy offers gait training through electrically driven movement mechanisms through two footrest platforms, a bodyweight support structure, an operation panel, and a computer-controlled operation and control unit.[10] Thus, GS moves the lower limbs of individuals according to a pattern previously determined by the physiotherapist, from the possibilities provided by the software,[11] where the mechanics distributed to the feet through the platforms transmit to the lower limbs the stimulus of the lower limbs ground or up and down steps,[10] making the necessary adjustments to bring the walking pattern closer to the functional.[9]

OBJECTIVE

The aim of the present study is to investigate the combined effects of physiotherapy and GS robotic therapy on gait functionality in relation to balance and gait speed. The findings may contribute to confirm the efficiency of the protocol used or improve it, as well as increase clinical knowledge in the area and assist in the clinical practice of professionals working with robotic therapy.

METHODS

A retrospective observational study was carried out through the analysis of medical records of institutionalized patients at the IMREA HC FMUSP, São Paulo – Brazil, being approved by the Research Ethics Committee of the University of São Paulo, under opinion CAAE: 96949118.0.0000.0068.

Thus, 51 records were initially selected for analysis, referring to individuals with ISCI, who performed at least one robotic training session in the GS from July 2013 to December 2018.

Of these, 10 were excluded for not completing the 20 sessions. therapy in robotic equipment, 3 due to clinical complications during the sessions, 3 for not presenting pre- and post-protocol evaluation data, 2 for being in therapy sessions during the data collection period, 2 for not meeting the eligibility criteria, 2 for having performed GS robotic therapy after the end of physical therapy and 1 for participating in an experimental protocol involving the use of biofeedback with the GS.

Thus, 28 records remained of individuals who completed the 20 robotic therapy sessions, where 14 were later excluded due to failure to perform assessments at the beginning of physiotherapy and before or after the 20 sessions of GS. Thus, the analysis of the results was based on a sample of 14 individuals in the chronic phase of ISCI, with a mean age of 42.35 ± 14.49, 10 men and 4 women.

The GS robotic gait[10] associated with conventional physical therapy was used as a therapeutic intervention, so that the participating individuals performed two sessions in the week of conventional physical therapy, lasting 50 minutes each, consisting of stretching, strengthening and global mobilization exercises body awareness exercises, independence and safety training for daily living activities, functional, cardiorespiratory and task-oriented training, including the use of functional electrical stimulation, lower limb cycle ergometer.

For robotic GS therapy, 20 sessions of 20 minutes each, twice a week, were performed, which may include gait, up and down steps, being at the discretion of each physiotherapist about the modality used according to each patient's assessed need. In addition, because this study was retrospective, it was not possible to control the length of time individuals spent performing each GS modality. In addition, the body weight support provided by the suspension present in the equipment was used only as a safety device, through a vest attached to the individual during training.

As an analysis of the effect before and after robotic gait therapy associated with conventional physiotherapy, we used the 10WT[12] and the BBS.[13] The medical record evaluations were performed by different researchers who performed the application of the scales during the participation period of the rehabilitation protocol.

Data analysis was performed using the SigmaStat program, where the normality of the distribution of variables was tested by the Kolgomorov-Smirnov method. However, due to the non-normal distribution of variables, to compare pre and post intervention effects, the Wilcoxon test was used, where p values <0.05 were considered statistically significant.

RESULTS

The sample consisted of 14 individuals, with an average of 33.14 ± 22.01 months of injury, from the episode of the injury and the beginning of robotic therapy, where all had incomplete paraplegia and were classified according to the American Spinal Injury Association (ASIA)[14] as ASIA C and D, that is 3 individuals were identified with an incomplete sensory and motor injury, ASIA C; and 11 as ASIA D due to an incomplete injury with preserved motor function below the injury level.

From this, Table 1 indicates the initial results of conventional physical therapy, and pre and post 20 sessions of GS robotic therapy associated with it.

It was observed that the individuals showed significant differences in the tests performed. The 10WT presented a mean velocity at the beginning of conventional physiotherapy of 2.60 m/s (± 1.72) and at the end of 20 GS sessions of 1.57 m/s (± 0.80), with p = 0, 0424.

At the beginning of GS robotic therapy, it presented a mean velocity of 2.04 (± 1.37), with p = 0.0152 when compared to the beginning of conventional physiotherapy and p = 101, which was not significant, comparing at the end of the 20 sessions.

GS Regarding BBS, the mean value at the beginning of conventional physical therapy was 31.85 points (± 12.50) and 42.35 (± 14.25) at the end of the 20 GS sessions, with p = 0.0096.

At the beginning of GS robotic therapy, it presented a mean value of 37.57 (± 13.05), with p = 0.0148 when compared to the beginning of conventional physiotherapy and p = 0.1278, when compared to the end of the 20 GS sessions.

Table 1. Comparison of results at the beginning of conventional physiotherapy, before and after GS robotic therapy

Scales Used	Variable	N = 14 Mean and Standard Deviation	≠ Start, Pre and Post p Value
10WT (m/s)	Start FC	2,607 ±1,72	0,56; p = 0,0152*
	Pre 20 sessions GS	2,047 ±1,37	0,473; p = 101*
	Post 20 sessions GS	1,574 ±0,80	1,033; p = 0,0424*
BBS	Start FC	31,857 ±12,50	5,714; p = 0,0148*
	Pre 20 sessions GS	37,571 ±13,05	4,786; p = 0,1278*
	Post 20 sessions GS	42,357 ±14,25	10,5; p = 0,0096*

*10WT: 10 meter walk test; m/s: meters per seconds; FC: conventional physiotherapy; GS: G-EO System; *: Wilcoxon*

DISCUSSION

As mentioned earlier, gait recovery and related functions, such as balance and mobility, are priorities for people with ISCI.[15] Thus, there is a paradigm in the rehabilitation process, where specific task training is expected the recovery of an identified and / or desired function.[16]

The use of conventional physiotherapy together with the GS robotic therapy has brought the possibility of increased gait speed, as well as improvement of static and dynamic balance in different postures in individuals in chronic phase of incomplete paraplegic spinal cord injury.

Gait training, climbing and descending steps allows task-oriented training and reinforcement of motor memory in the performance of these activities.[17] In addition, the practice of these exercises helps in strengthening the core and lower limb muscles,[17] so that these muscles are essential for maintaining balance and consequently influence gait.

In addition, the use of gait training through robotic therapy is an additional treatment opportunity for individuals with axial disorders, increasing the challenge of training by imposing specific kinematic parameters, and providing intensive and somatosensory cues.[18] Along with this, a good balance is essential for individuals with spinal cord injury (SCI) to regain their mobility and independence.[19]

The GS is considered as a robot that has the end-effector feature that is through modular platforms attached to the feet of individuals, it modulates the gait in relation to speed and stride length.

This equipment allows the person to remain freer to perform the activity when compared to exoskeleton robots. Thus, the GS allows greater trunk oscillations and voluntary activation of the core and lower limb muscles, so that the individual can perform the task with maintaining balance and voluntary control of the adjacent structures.[20]

With the motor limitations installed after SCI, individuals who remain with the ability to move, move with decreased gait speed and resistance, directly impacting their social participation and functional independence.[21] Therefore, these are indicative important for, since the goal of treatment is to enable them to safely and easily walk with a good functional speed as far as possible.[22]

Thus, the association of conventional physiotherapy with robotic therapy GS, proved to be effective in improving these aspects in the sample, because the robotic device generates a precise, repetitive and intense cycle of gait phases, also helps in motor relearning through neuroplastic promotion of the pathways involved in this process, and functional improvement of this skill.[20]

Along with gait training, the main differential of the GS is the step up and down training, which can in turn increase the muscle strength, coordination, balance and cardiorespiratory conditioning of individuals practicing this mode.[19] Concomitantly therefore, ground gait training performed through conventional physiotherapy has been suggested as a positive reinforcer of the tasks performed during robotic therapy, bringing benefits to gait balance and functionality in individuals with incomplete chronic SCI,[22] based on In principle, they will not be coupled to a body weight adjuster during their daily gait and associated tasks, where independent weight bearing assists in obtaining physiological adaptations through progressive overload, improving the maintenance of postural orientation and balance during functional walking.[22]

Finally, this was the first study conducted and found in the literature using the GS as an adjuvant therapy in the rehabilitation process of the population with chronic incomplete spinal cord injury. In addition, the study has several limitations, including the individual delimitation by each physiotherapist of the robotic therapy protocol performed.

It is worth remembering that, by performing a retrospective analysis on equipment routinely used in the institution, it was not possible to control the speed used, length of stay in each type of equipment. It was not possible to use a control group, thus making it impossible to describe and separate motor gains due to robotic therapy and conventional therapy. Thus, the present study group is in the process of conducting new research with advances in these aspects, so that in the future new studies are produced with less limitations.

Therefore, gait training through robotic therapy and using body weight support has shown promising results, but it is still unclear whether these results are superior to conventional physiotherapy,[23] but what this study shows are the good ones results towards the improvement of the functionality of the individual, from the combined therapies.

CONCLUSION

The use of GS robotic therapy in gait, climb and descent steps in addition to conventional physiotherapy has been shown to be effective in promoting balance and gait speed in chronic phase individuals with incomplete spinal cord injury, with significant increases in 10WT scores and the BBS.

Thus, robotic therapy as a form of intervention made evident the good use of the resource as a complementary therapy to the conventional rehabilitation process, directly implying the improvement of quality of life and functional independence of individuals.

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