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ARTIGO ORIGINAL

Treino de marcha com suporte parcial de peso em esteira ergométrica e estimulação elétrica funcional em hemiparéticos

Bodyweight supported treadmill training associated with functional electrical stimulation in hemiparetic patients

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RESUMO

Introdução: A perda da habilidade locomotora em indivíduos com Acidente Vascular Encefálico (AVE) tem sido atribuída a hemiparesia, a mais comum causa de comprometimento pós AVE. Novas abordagens, como o treino de marcha utilizando o Suporte Parcial de Peso (SPP) em uma esteira ergométrica associada com a Estimulação Elétrica Funcional (FES) tem sido sugerido como um método de reabilitação da marcha em pacientes hemiparéticos. O objetivo deste trabalho foi avaliar a eficiência do treinamento de marcha com SPP em esteira ergométrica associado ao FES em pacientes hemiparéticos. Métodos: Foram selecionados aleatoriamente 14 sujeitos com hemiparesia decorrente de acidente vascular cerebral. A escala de Desempenho Físico de Fugl-Meyer, a escala de Equilíbrio de Berg, a escala de Categorias de Deambulação Funcional e uma avaliação da cadência foi utilizada como instrumento de medida. Foram realizadas quatro avaliações com os sujeitos da pesquisa, a primeira (controle) realizada antes e a segunda (pré-tratamento) depois do tratamento fisioterápico tradicional, a terceira (pós-tratamento) após o treinamento de marcha com SPP em esteira ergométrica associado ao FES (20 sessões), e há quarta (retenção), trinta dias após o término do tratamento. Resultados: O treinamento proposto apresentou melhora significativa (p-valor >0,05) na velocidade da marcha, na cadencia, no equilíbrio e no nível de comprometimento motor, mantendo os resultados após 30 dias. Conclusão: O treinamento de marcha com SSP em esteira ergométrica associado ao FES é eficaz na reabilitação da marcha em hemiparéticos.

PALAVRAS-CHAVE

acidente cerebrovascular, estimulação elétrica, marcha, teste de esforço

ABSTRACT

Introduction: The loss of the ambulation capacity in individuals with Cerebrovascular Accidents (CVA) has been attributed to hemiparesis, the most frequent cause of post-CVA impairment. New approaches, such as the bodyweight supported treadmill training (BWSTT) associated with functional electrical stimulation (FES), have been suggested as a gait rehabilitation method for hemiparetic patients. Objective: The aim of the present study was to evaluate the efficacy of the BWSTT associated to FES in hemiparetic patients. Methods: Fourteen individuals with hemiparesis due to CVA were randomly selected. The Fugl-Meyer Assessment of Sensorimotor Impairment (Fugl-Meyer Scale), the Berg Balance Scale, the Functional Ambulation Category Scale and the cadence assessment were used as measurement tools. The study subjects underwent four evaluations: the first (control) carried out before and the second (pre-treatment) after the conventional physical therapy, the third (post-treatment) after the BWSTT associated to FES (20 sessions) and the fourth (retention), 30 days after the end of the treatment. Results: The proposed training showed a significant improvement (p>0.05) in gait velocity, cadence, balance and motor impairment level and the results persisted 30 days after the end of the treatment. Conclusion: The BWSTT associated with FES is effective for gait rehabilitation in hemiparetic individuals.

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KEYWORDS
cerebrovascular accident, electric stimulation, gait, exercise test

INTRODUCTION

Hemiplegia and/or hemiparesis is one of the most common clinical signs of the encephalic vascular accident (EVA), characterized by the total or partial loss of the motor function, resulting in several levels of impairment and disability.[1] Motor recovery occurs after a sequence of events initiated by a flaccid phase, followed by an increase in abnormal synergies of movement, with subsequent decrease in the synergies and improvement of the selective control of movement.[2]

The loss of the capacity to ambulate independently is one of the most common consequences of an EVA.[3] At the moment of hospital admission, 51% of the patients do not present gait function and another 12% need help to ambulate.[4] The gait deficit resulting from hemiparesis and/or hemiplegia is caused by the decrease in the voluntary muscle control and the onset of hyperactive stretching reflexes,[5] which limit the movements of the limbs and the viable use of residual motor function.[3]

Hemiplegic individuals present an assortment of limitations, but they elect the gait function improvement as the main objective in their rehabilitation process. Different approaches are employed in an attempt to address these needs, such as neurofacilitation (Brunnston, Proprioceptive Neuromuscular Facilitation) and neurodevelopmental techniques; however, these techniques do not show satisfactory results regarding gait rehabilitation.[2]

The conventional gait training often leads to an asymmetric gait pattern in most individuals with EVA.[6] Some approaches have been suggested, aiming at eliminating these abnormal patterns.

The functional electrical stimulation (FES) has been successfully used in hemiparetic individuals for the prevention of equinovarus foot, to restore the normal patterns of movement and to promote muscular strength recovery.[7]

The use of partial body weight support (BWS) on the ergometric treadmill for gait training in hemiparetic individuals has been employed. This technique is based on the peripheral sensory stimulation as the promoter of neuroplastic responses that supply the return of the motor response.[8]

Considering all these facts, the aim of this study is to evaluate the efficiency of a bodyweight-supported treadmill training associated with FES in hemiparetic individuals.

METHODS

A total of 14 individuals of both sexes aged 18 to 60 years and that presented hemiparesis due to EVA were studied. The subjects were randomly recruited at the Outpatient Clinic of Physical Therapy and Occupational Therapy of Hospital de Clínicas of the University.

All the individuals were at the chronic phase of recovery (>365 days) with only one episode of EVA. The subjects with previous neurological disorders, orthopedic alterations, cognitive deficits and psychiatric problems were excluded from the study. The project was approved by the Ethics and Research Committee of the institution (569/2004).

Measurement Instruments

The Fugl-Meyer[9] Physical Performance (PP) protocol was used to evaluate the sensorimotor impairment of the lower limb and balance. There are 17 items for the lower limb and 7 for balance, in a score that goes from zero to 2, totaling 34 and 14 points, respectively.

Balance was assessed through the Berg Balance Scale (BBS),[10] which uses 14 items scored zero to four, with a total of 56 points. The BBS and the Fugl-Meyer protocol were chosen because they meet the criteria of reliability, validity and precision, as well as the fact that their original versions were translated into Portuguese and their reproducibility tests were performed in Brazil;[9,10] they have also been previously used in clinical research in our country.[11]

The Functional Ambulation Category (FAC) scale was used to assess the necessary support for the patient to walk, following a six-level scale: level 0 – the individual cannot walk or requires the help of two or more people; level 1: the individual requires continuous support from one person to help him/her with the bodyweight and balance; level 2: the individual depends on one person for continuous or intermittent support for balance or coordination; level 3: the individual only needs verbal supervision; level 4: help is required for stair climbing and irregular surfaces; level 5: the individual can walk independently anywhere.[12] The FAC scale was selected as it is a reliable and valid measurement tool, having been constantly used in studies on gait rehabilitation in hemiplegic individuals.[13]

To evaluate gait cadence, the number of steps that are necessary to walk a distance of 10 meters was analyzed. The gait velocity was measured by dividing the walked distance (10 meters) by the time spent during the walk. The cadence and velocity values were calculated as the mean value obtained after three repetitions.[14]

Procedures

After the selection, the individuals were submitted to four assessments carried out by physical therapists unrelated to the research. The assessments were carried out through the use of the aforementioned scales.

The initial assessment (control) was carried out before any therapeutic intervention. After 20 sessions (twice a week) of traditional physical therapy based on the Bobath neuroevolution concept[15] and the proprioceptive neuromuscular facilitation techniques,[16] a second assessment (pre-treatment) was performed. After this second assessment, the bodyweight supported treadmill training (BWSTT) associated with FES was started, with a duration of 20 minutes in a total of 20 sessions (twice a week). The third assessment (post-treatment) was performed at the end of the training. Afterward, the individuals received the conventional physical therapy for a period of 30 days, having received directions for at-home activities and returning at the end of the period to undergo the fourth assessment (retention).

Bodyweight supported treadmill training associated with FES

The patients underwent a stretching session upon arriving at the Service of Physical Therapy and Occupational Therapy of Hospital das Clinicas. After that, the patients were adjusted to the bodyweight support (BWS) on the ergometric treadmill and the FES was positioned on impaired lower limb.

The partial BWS was 40% at the start of the training and it was progressively decreased for each patient as the gait pattern and capacity improved. The gait capacity and pattern on the treadmill were based on the capacity to maintain the extension of the hip and knee, without hyperextension, while the weight was loaded on the impaired leg[17] and the capacity to produce the step. The treadmill velocity was the fastest possible, respecting the maintenance of an adequate step length.

The use of FES was carried out through an electrode positioned on the belly of the anterior tibial muscle and another on the fibular nerve (upper third of the leg, just below the fibular head). A wavelength of 250µS and a frequency of 30 Hz were used. The support and resting time was cycled with the phase of oscillation and support, respectively. The intensity was increased until an effective dorsiflexion was reached.

Data Analysis

The *t*-test for paired samples with comparison of means was used to assess the gait cadence and velocity data. The level of significance for the statistical tests was set at $p<0.0001$.

Friedman's test was used for the FM, Berg Balance Scale and FAC data at the four assessments. When statistically significant differences were observed between assessments, Wilcoxon's test was used. These tests were used due to the absence of normal distribution of some scores and the small sample size. The level of significance for the statistical tests was set at 5%, or $p<0.05$.

RESULTS

Fourteen individuals were assessed during 20 sessions. Of the assessed individuals, 10 were males and 4 were females; the mean age was 45 years, the mean lesion time was 4.3 years and regarding the motor deficit, 10 individuals presented hemiparesis on the right side and 4 on the left.

Regarding the subsection of lower limb at the FM scale, a statistical difference was observed only between the first assessment (control) and the post-treatment one ($x^2 = 10,7786$; $p = 0.0167$). No statistical difference was observed between the other assessments (Figure 1).

At the balance subsection of the FM scale, no statistical difference was observed between the assessments. However, when balance was assessed by the Berg Balance Scale, there was a significant difference between the control and post-treatment assessments and between the control and retention ($x^2 = 23,6786$; $p = 0.0022$) and between the pre-treatment and retention assessments ($x^2 = 23,6786$; $p = 0.0051$) (Figure 2), but no difference was observed between the pre- and post-treatment assessments.

Regarding the FAC, there was a significant difference between the control and the post-treatment assessments, between the control and the retention assessments, pre-treatment and post-treatment assessments ($x^2 = 28,9714$; $p = 0.0015$).

The velocity showed differences between the pre- and post-treatment and between the pre-treatment and retention ($p < 0.0001$) (Figure 3). There was no statistical difference between control and pre-treatment or between the post-treatment and retention assessments.

Cadence showed a significant decrease between the control and the post-treatment assessments, as well as between the pre- and post-treatment assessments ($p < 0.0001$). No significant change was observed between the control and the pre-treatment assessments, or between the post-treatment and the retention assessments (Figure 4).

DISCUSSION

Independent ambulation is directly correlated with balance and the motricity of the lower limbs.[18,19] Bohannon[20] attributes the capacity to ambulate in individuals with hemiplegia to the balance and their level of motor impairment.

In the present study, gait improvement through ergometric treadmill training with partial BWS and FES, was followed by the decrease in the levels of motor impairment in the lower limb and balance increase measured through the FM scale of physical performance and the Berg Balance scale.

Studies suggest that one of the main impairments that contribute to gait disorders in hemiparetic individuals is the loss of selectiveness of the motor result (the co-contraction component), of which outcome is the loss of the motor fractioning, caused by corticospinal lesions that manifest as walking through total extension or flexion.[21]

Even with the lack of reports in the literature that correlated the level of sensorimotor impairment and balance with partial BWS treadmill training and FES, it can attributed to the treatment used, which provides a longer periods of unipodal support, increased unlo-

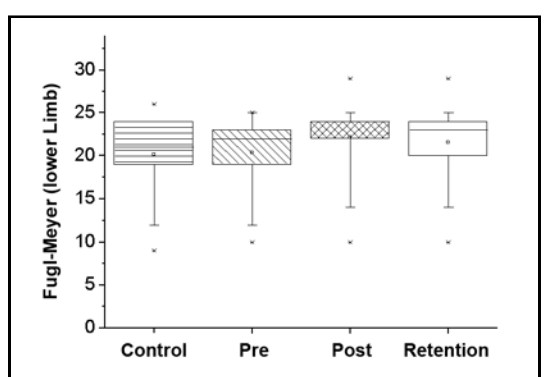

Figure 1
Chart illustrating the score obtained at the lower limb subsection of the Fugl-Meyer Scale at the four evaluations (p<0.05): first evaluation (control), second evaluation (pre-treatment), third evaluation (post-treatment) and fourth evaluation (retention).

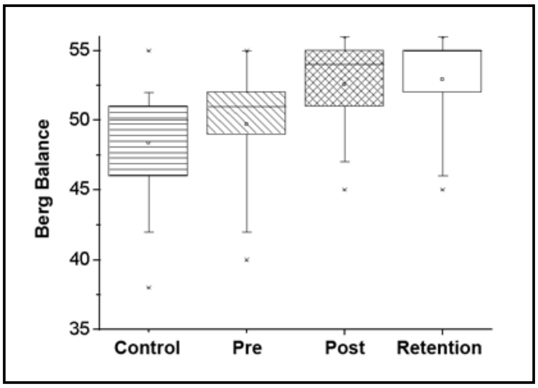

Figure 2
Chart illustrating the score obtained at the Berg Balance Scale at the four evaluations ($p<0.05$): first evaluation (control), second evaluation (pre-treatment), third evaluation (post-treatment) and fourth evaluation (retention).

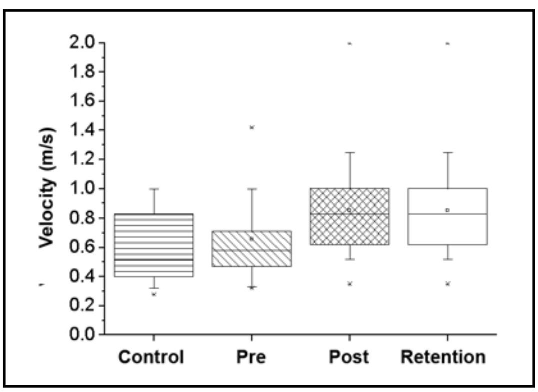

Figure 3
Chart illustrating gait velocity at the four evaluations ($p < 0.0001$): first evaluation (control), second evaluation (pre-treatment), third evaluation (post-treatment) and fourth evaluation (retention).

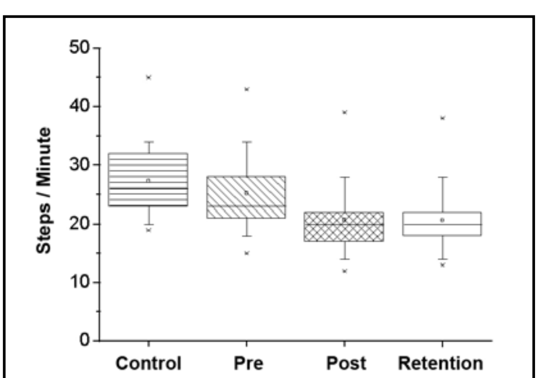

Figure 4
Chart illustrating gait cadence at the four evaluations ($p < 0.0001$): first evaluation (control), second evaluation (pre-treatment), third evaluation (post-treatment) and fourth evaluation (retention).

ading on the affected side and more symmetrical gait. Additionally, it is indicative of a modulation of the central nervous system due to the repetitive gait training, as show in previous studies,[6,22] which demonstrated a satisfactory result with decreased co-contraction of the antagonist muscles of the ankle and more adequate control of the phasic pattern.

The present study demonstrated an increase in velocity, as shown in Figure 4, which, in part, might have favored the increased step length and cadence on the ground. Two other factors that seem to have contributed to this increase were the balance improvement, which allows a better unipodal support in the affected lower limb and the use of FES, which according to Glanz et al[7] has the potential to increase gait velocity and quality.

The study by Lindquist et al,[23] carried out in two hemiparetic patients, suggests that the association of BWS and FES improves the cycle duration and velocity, as well as the step support and cadence time in both limbs, in addition to the improvement in the spatial-temporal variable of the hemiparetic gait.

Kottink et al[24] also demonstrated that the use of FES on the gait training of hemiparetic patients decreases the energy consumption of the hip and knee muscles, producing fewer compensatory movements and resulting in better functional ambulation, in addition to a mean increase of 14.8% in gait velocity.

The BWS treadmill training associated with FES resulted in the improvement of all the assessed functional items. These data are in accordance with recent studies[2] that attribute this improvement to the support and stability provided by the technique. Yan et al[25] also believe that the repetitive movements of the affected lower limb of hemiplegic individuals, induced by FES, can reinforce the pattern of neural connections and help in the gait improvement and acquisition.

Although gait symmetry was not analyzed, its significant improvement was observed and it might have been caused by the increase in gait velocity. It has been reported[26] that after the EVA, there is a highly dependent correlation between walking and the velocity, as the individuals who walk faster tend to be less asymmetric than those who walk slowly, suggesting that the improvement in walking can be caused by an increase in the velocity to an ideal level.

Several researchers have demonstrated an association between velocity and the characteristics of walking in a group of patients with hemiparesis after EVA.[27] The changes in walking associated to the increase in the velocity included the higher extension of the hip in the terminal vertical posture and an increase in the flexor moment of the hip at the start of the swing phase, as well as alterations in the length and frequency of the steps.[28]

The BWS treadmill training associated with FES can dispose instruments that facilitate the process of motor relearning of the gait process, as the capacity to offer an adequate gait pattern and repeat it. The training offers a support and oscillation phase to the affected lower limb similar to that observed in normal individuals, reducing the double support period, commonly increased in hemiplegic gait. It is also accompanied by a complete oscillatory phase, which is facilitated by the hip extension and stimulation of the fibular nerve.

In the present study, all individuals presented more than 2 years of hemiplegia and had been discharged from the physical therapy treatment. The return to the treatment (conventional physical therapy) contributed to the final result, shown by the significant improvement in the lower limb subsection of the FM scale and the Berg Balance Scale, between the control assessment and the post-treatment one. It is not possible to determine the exact contribution, but it is believed to have been significant and it must be employed together with BWS treadmill training and FES.

It was not possible to determine and/or verify the development of a plateau in the motor recovery of the individuals during the study, after the conventional physical therapy treatment, or after the BWS treadmill training and FES. Perhaps under distinct conditions – higher intensity, repetitions, duration and frequency – it might be possible to observe better results or determine the presence of a plateau. It is known that the motor recovery in hemiparetic individuals undergoes the same adaptation processes that occur during the training of healthy individuals. The plateaus are common to all areas of neuromuscular training, with some peak levels in response to training with constant stimulation, presumably due to a neuromuscular adaptation.[29]

CONCLUSION

Considering the proposed objective and the results obtained, it is possible to affirm that partial bodyweight-supported treadmill training associated to FES resulted in significant increase in gait velocity, cadence and functionality as well as in balance improvement, with consequent decrease in the motor impairment level. Additionally, it can be used as an accelerator agent in the rehabilitation process, as it results a faster response when compared to the conventional treatment.

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