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Immediate effects of functional electrical orthoses in gait of hemiparetic patients

Efeitos imediatos do uso de órtese elétrica funcional na marcha de pacientes hemiparéticos

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ABSTRACT

Introduction: Functional electrical orthoses may favor ankle dorsiflexion in hemiparetic patients. Objective: The objective of this study was to evaluate the immediate effects of using the functional orthosis in the gait of hemiparetic patients. Methods: The research was performed on 10 participants with diagnosis of hemiparesis. The participants selected for this research were evaluated both with and without the use of the WalkAide® System functional electrical orthosis conducted via the 10-meter walk test and baropodometry. Results: The samples of this study were characterized by male participants averaging in age from 52,7 ± 15,3 years. The participants presented an inferior displacement time (25,64 ± 11,42 s) with the use of the functional electrical orthosis when compared to the displacement time without the orthosis (27,68 ± 12,99 s). With regards to the baropodometric data, there were significant differences in the contact area of the forefoot and the hindfoot with the use of the functional electrical orthosis. Conclusion: Functional electrical orthosis yielded immediate satisfactory results in the gait of hemiparetic patients.

KEYWORDS: Stroke; Gait; Electric Stimulation; Orthotic Device; Physical Therapy Specialty.

RESUMO

Introdução: As órteses elétricas funcionais podem melhorar a dorsiflexão de tornozelo em pacientes hemiparéticos. Objetivo: O objetivo deste estudo foi avaliar os efeitos imediatos do uso da órtese elétrica funcional na marcha de pacientes hemiparéticos. Métodos: A pesquisa foi realizada com 10 participantes com diagnóstico de hemiparesia. Os participantes selecionados foram avaliados com e sem o uso da órtese elétrica funcional WalkAide® System através do teste de caminhada de 10 metros e da baropodometria. Resultados: A amostra deste estudo foi caracterizada por participantes masculinos com média de idade de 52,7 ± 15,3 anos. Os participantes apresentaram um tempo de deslocamento inferior com o uso da órtese elétrica funcional (25,64 ± 11,42 s) quando comparados com o tempo de deslocamento sem a órtese (27,68 ± 12,99 s). Com relação aos dados baropodométricos, houve diferenças significativas na área de contato do antepé e do retropé com o uso da órtese elétrica funcional. Conclusão: O uso do WalkAide® System demonstrou resultados imediatos satisfatórios na marcha de pacientes hemiparéticos.

PALAVRAS-CHAVE: Acidente Vascular Cerebral; Marcha; Estimulação Elétrica; Aparelhos Ortopédicos, Fisioterapia.

INTRODUCTION

Stroke is a serious public health problem in Brazil and worldwide, possibly resulting in partial or total neurological sequelae, considerably incapacitating. According to the Brazilian National Health Research, at present, 2.231.000 people have stroke in Brazil, of these, approximately 25% shows serious incapacities[1]. Stroke is defined as a neurological dysfunction, global or focal, of vascular origin which lasts more than 24 hours, that may lead to death or to the compromising of cognitive, motor, psychological and social functions[2].

Within the main post-stroke hindering symptoms, is hemiparesis, corresponding to 80% of neuromotor sequelae. Hemiparesis is the unilateral compromising of the upper and lower limbs on the same side of the body, characterized mainly by, the presence of postural asymmetry. Although the majority of hemiparetic patients may acquire independent walking, most patients present limitations in gait patterns due to muscle weakness, knee, hip and ankle joint angular limitations, spasticity and, mainly, dynamic balance déficit[3]. Dobkin et al. (2004)[4] additionally claim that these functional alterations may lead to foot drop, resulting in reduced speed, rhythm and step length during walking.

As a result, new therapeutic technology has been proposed in the rehabilitacion of hemiparetic patients. In this context, the use of functional electrical orthoses, a small device which supplies electrical asymmetrical biphasic stimulation of surface, in a synchronized manner in order to activate ankle dorsiflexion during the weight-shifting in gait balance, through stimulation of the common fibular nerve[5]. Supplementary to being a discreet, easy and practical to handle equipment, recent studies have shown that the functional electrical orthosis yields positive outcomes in the increase of active dorsiflexion angles[6, 7], reduction in spasticity[8] and increase in gait speed[5, 9-11] after, at least, a two-month period. Although there have been favorable and recent scientific evidence, few studies have verified the final results obtained after a short time period using these tools in the gait of post-stroke patients. Bearing this in mind, the overall goal of this study was to evaluate the immediate effects of using the functional electrical orthosis in the gait of hemiparetic patients.

METHODS

This study was characterized by an almost-experimental research, having a quantitative approach. All the participants were informed of its objective and procedures. The study was approved by the Ethics and Research Committee at Feevale University (CAEE 64995317.4.0000.5348).

The research was performed on 10 participants deriving from a physiotherapy clinic-school of a university in the South of Brazil, and that fit the following inclusion criteria: above 18 years of age, diagnosis of functional hemiparesis resulting from a stroke, ability to understand and follow simple verbal instructions, a score of, at most, 3 points, in the Modified Ashworth scale, ability to walk 15 meters without the use of a walking device, and a formal signed agreement for taking part in the study, using the form Informed Consent Form. Individuals that had undergone recent surgery, being under the effect of Botulinum toxin type A on the lower limbs for the last 6 months or other medications which could interfere with dynamic balance, and those who were at risk of receiving electrical currents were excluded from the study. The selected participants who took part in the research were evaluated both with and without the use of the functional electrical orthosis WalkAide® System.

Previous to placing the functional electrical orthosis, the skin around the head of the fibula was wiped clean with a 70% alcohol solution. The patient was told to sit comfortably in a chair and the cuff of the equipment was positioned below the knee following factory instructions[12]. The stimulation intensity was adjusted individually, considering the level of comfort and the efficiency of the dorsiflexors contraction. It is appropriate to highlight that, for the sake of adaptation, all the participants wore the functional electrical orthosis during five (5) minutes before the placement of the evaluation instruments.

The instruments used for obtaining the data were: the 10-minute walk test and baropodometry. In order to register the collected data, all the tests were recorded using a digital camera, SONY®, Cyber-shot (16,1 megapixels), positioned on a tripod in front of the participant. The 10-meter walk test (10MWT) followed the criteria described by Salbach et al. (2001)[13]. The evaluation took place in a 14-meter long leveled area. Using a Motorola G3 digital stopwatch, the needed time to cover the 10 meters in-between was documented, being that the initial and final 2 meters were ignored. All the participants received the following standard instructions given by the researcher: “Mr. Miss or Mrs., do you see that 1,2 m mark ahead of you?” “Please position yourself on the mark and begin walking at your normal speed coming to a stop only at the 1,2 meter mark on the other end.” “Please begin walking as soon as you are ready.”.

Later, during the realization of the 10MWT the participants were submitted to dynamic baropodometry. Dynamic baropodometry is a sensitive system which measures the distribution of plantar pressure during the static standing and during gait[10, 14]. For this analysis, the researcher made a mark three meters before and two meters past the baropodometric platform (EPS, Kinetec®), which was placed on the floor, on a plane surface connected to the Biomech Studio® software. Following standardized commands, the participant was told to walk at their usual gait velocity and specifically step on the baropodometer with the side of the foot that is compromised. In addition to the qualitative images, the output generated by the baropodometer made possible to capture the following variables: percentual (%) forefoot contact area, middle-foot, hindfoot and elapsed time of the step.

The collected data was organized into the Microsoft Excel 2013®. The descriptive statistics of the analyzed data were presented through estimated averages and the corresponding standard deviations. By presenting normal distribution, the analyzed variables in the 10MWT and in the baropodometric evaluation were compared prior to and during the use of the functional electrical orthosis by means of the paired-t test. In all the statistic tests utilized, a 5% ($p < 0,05$) level of significance was taken into account. Graph Prism 7 software was used for the analysis and graphic elaboration.

RESULTS E DISCUSSION

This study was predominantly composed of male subjects averaging from 52,7 ± 15,3 years of age (Table 1). As regards to the functional profile, the study comprised mainly, patients with a post-lesion time of over 2 years (83,3%), with a considerable increase in plantar flexor tonus (level 3), according to the Modified Ashworth scale (50%) and hemiparesia to the left (66,7%).

Table 2 summarizes the variables related to the 10MWT and the dynamic baropodometry. After employing the paired-t test, it is evident that the participants presented an inferior displacement time (25,64 ± 11,42 s) with the use of the functional electrical orthosis when compared to the displacement time without the orthosis (27,68 ± 12,99 s).

Table 1. Functional profile of the participants of the study

Variable	Characteristic	%
Type of stroke	Hemorrhagic	50,0
	Ischemic	50,0
Post-lesion time	≤ 2 years	16,7
	≥ 2 years	83,3
Lesional Topography	Right parietal lobe	50,0
	Left parietal lobe	33,3
	Brainstem	16,7
Level of spasticity	3	50,3
	2	33,3
	1+	16,7
Hemibody affected	Left	66,7
	Right	33,3

Table 2. Average and standard-deviation of variables

Variables	Without orthosis	With orthosis	p-value
Surface area of the forefoot (%)	43,61 (6,94)	42,55 (7,35)	0,03*
Surface area of the middle-foot (%)	24,84 (4,99)	24,59 (4,86)	0,69
Surface area of the hindfoot (%)	33,18 (3,94)	34,42 (4,49)	0,02*
Elapsed time of the step (ms)	1496 (850)	1505 (943,58)	0,89
10-meter walking test (s)	47,58 (47,21)	38,91 (35,05)	0,03*

p-value: significance level. The statistical significance is marked with asterisks.

The gait velocity is an important indicator of mobility and functionality in hemiparetic patients[9]. Studies[5, 6, 11, 15] have consistently demonstrated that the use of functional electrical stimulation produce positive effects in the gait of patients with neurological dysfunctions, including significant changes in displacement time and in walking speed. In a multi-centre clinical trial, Stein et al. (2006) demonstrated that gait velocity in patients with foot drop increased by 15% and 32% after the use of the functional electrical orthosis during 3 and 6 months, respectively, thus suggesting effects directly linked to use and training[5].

It is worth noting that, with the purpose of considering the clinical applicability and the use of the therapeutic device WalkAide®, the aim of this study was to evaluate the immediate effect of the functional electrical orthosis in untrained individuals. Presently, only the study of Miller et al. (2014) proposed to evaluate the effects of the functional electrical orthosis within the first two minutes of use in patients having multiple-sclerosis[16]. Based on this investigation, the authors concluded that a functional electrical stimulation produced satisfactory outcomes in terms of energetic expenditure and gait velocity.

Some mechanisms of action have been proposed to explain the influence of these devices in the gait parameters, including the increase of electromyographic activity level of the peripheral nerves[17] and the cortex excitability[18]. Yamaguchi et al. (2012)[18] additionally suggest that electrical stimulation may result in beneficial effects for the control of spasticity of the plantar flexors by stimulating the tibialis anterior muscle, hence favoring improvement in the walking speed of post-stroke patients.

Concerning the baropodometric data, the statistical analyses presented no difference in the variables of surface area of the middle-foot and elapsed time of the tread when compared to using the functional orthosis or not. However, there were substantial differences in the forefoot surface area and the hindfoot when utilizing the functional electrical orthosis.

Dynamic baropodometry is a sensitive system that measures the distribution of plantar pressure both during the static standing and gait. The posturographic data of body weight distribution shows a good correlation with other gait parameters and with the severity of neurological deficit. However, until recently, few studies utilize this tool to evaluate structural and functional characteristics of hemiparetic patients[14, 19, 20]. The post-stroke foot drop is a result of weakness or lack of voluntary motor control of ankle and finger dorsiflexor muscles. These aspects hinder weight shift to the compromised side, contributing to an unstable and inefficient gait[21].

In our study, the increased surface area of the hindfoot can be explained by the activation of the dorsiflexor muscles and, consequently, a more effective ankle step induced by the functional electrical orthosis. In a randomized and multicentric clinical trial, Everaert et al. (2013)[6] observed that the electrical stimulation of the common peroneal nerve by means of the functional electrical orthosis, stimulated the active contraction of the dorsiflexors, optimizing the initial ankle contact and the initial phase of the gait. More recently, Daniilidis et al. (2017)[7] demonstrated that the functional electrical orthosis decidedly increased the amplitude of movement of dorsiflexion in initial walking phase by approximately 5 degrees.

Through a qualitative analysis of the gait (Figure 1) and the baropodometric data (Figure 2) it can also be observed that the dorsiflexion caused by the functional electrical stimulation during the midstance phase contributes directly for the user of the functional electrical orthosis to transfer more body weight to the affected limb, thus distributing the plantar pressure more evenly and modifying the center of pressure (CoP) or line of walking advancement.

Figure 1 - Comparison of dorsiflexion during gait midstance phase without (A) and with (B) the functional electrical orthosis.

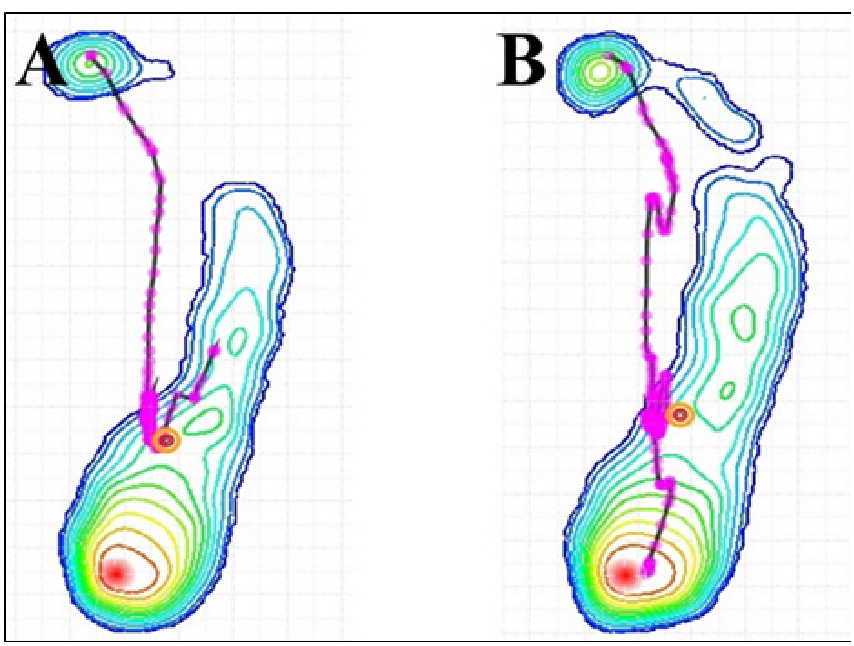

Figure 2 - Comparison of plantar pressure distribution lines and the influence on center pressure line (CoP) of step without (A) and with (B) the functional electrical orthosis.

In conjunction with the increase of the surface area with the hindfoot, the use of the functional electrical orthosis favored a reduction in surface contact area of the forefoot. Some authors[10, 22] have observed that hemiparetic patients yield greater peaks of pressure in the forefoot. The authors attribute this fact to equinism and spasticity which are common in hemiparetic patients, as well as to coordination deviation, sensorial alteration, and insufficient weight shift to the debilitated side.

Nowadays, few studies[23, 24] have also evaluated the influence of functional electrical stimulation in the symmetry and quality of walking in hemiparetic patients. Apart from modulating pressure, especially in the final support phase, the functional electrical orthosis improves the angles of hip and knee flexing and, consequently, the symmetry of these articular units during gait, promoting stability and reducing the risk of falls. Regarding spasticity, Burridge and McLellan (2000)[21] affirm that functional electrical stimulation may impact positively in spastic hypertonia of inferior limbs in post-stroke patients. The authors noted a spasticity inhibition in gastrocnemius and soleus muscles on the impaired side when the electrical orthosis was worn to trigger the tibialis anterior muscle.

CONCLUSION

On top of safeness and practicality, this study revealed that the functional electrical orthosis formed immediate satisfactory outcomes in the walking performance of hemiparetic patients, chiefly in gait velocity and distribution of plantar pressure. It is meaningful to take into account that this investigation presents some limitations, those being a small sample number and sample heterogeneity. Despite favorable evidence for the immediate clinical implementation of the functional electrical orthosis, there is yet additional investigation to be done in assessing the long term effects of functional electrical stimulation in the gait and in the quality of life of hemiparetic patients.

REFERENCES

1. Bensenor I, Goulart A, Szwarcwald CL, Vieira MLFP, Malta DC, Lotufo P. Prevalência de acidente vascular cerebral e de incapacidade associada no Brasil: Pesquisa Nacional de Saúde. Arquivos de Neuro-Psiquiatria. 2013;73(9):746-50.

2. Rodrigues VRMC, Quemelo PRV, Nascimento LCGd, Cecília M, Pereira S, Lopes MC, et al. Reabilitação da funcionalidade da marcha em hemiparéticos. Revista Neurociências. 2015;23(2):227-32.

3. Schepers VP, Ketelaar M, van de Port IG, Visser-Meily JM, Lindeman E. Comparing contents of functional outcome measures in stroke rehabilitation using the International Classification of Functioning, Disability and Health. Disabil Rehabil. 2007;29(3):221-30.

4. Dobkin BH, Firestine A, West M, Saremi K, Woods R. Ankle dorsiflexion as an fMRI paradigm to assay motor control for walking during rehabilitation. Neuroimage. 2004;23(1):370-81.

5. Stein RB, Chong S, Everaert DG, Rolf R, Thompson AK, Whittaker M, et al. A multicenter trial of a footdrop stimulator controlled by a tilt sensor. Neurorehabil Neural Repair. 2006;20(3):371-9.

6. Everaert DG, Stein RB, Abrams GM, Dromerick AW, Francisco GE, Hafner BJ, et al. Effect of a foot-drop stimulator and ankle-foot orthosis on walking performance after stroke: a multicenter randomized controlled trial. Neurorehabil Neural Repair. 2013;27(7):579-91.

7. Daniilidis K, Jakubowitz E, Thomann A, Ettinger S, Stukenborg-Colsman C, Yao D. Does a foot-drop implant improve kinetic and kinematic parameters in the foot and ankle? Arch Orthop Trauma Surg. 2017;137(4):499-506.

8. Khaslavskaia S, Ladouceur M, Sinkjaer T. Increase in tibialis anterior motor cortex excitability following repetitive electrical stimulation of the common peroneal nerve. Exp Brain Res. 2002;145(3):309-15.

9. Harris JE, Eng JJ, Marigold DS, Tokuno CD, Louis CL. Relationship of balance and mobility to fall incidence in people with chronic stroke. Phys Ther. 2005;85(2):150-8.

10. Schuster RC, Zadra K, Luciano M, Polese JC, Mazzola D, Sander I, et al. Análise da pressão plantar em pacientes com acidente vascular encefálico. Revista Neurociências. 2008;15(3):179-83.

11. Downing A, Van Ryn D, Fecko A, Aiken C, McGowan S, Sawers S, et al. Effect of a 2-week trial of functional electrical stimulation on gait function and quality of life in people with multiple sclerosis. Int J MS Care. 2014;16(3):146-52.

12. WalkAide® System User Manual. [Internet]. 2017. Available from: http://www.walkaide.com/support/Docu-

ments/UserManual_LM01_Rev8.pdf.

13. Salbach NM, Mayo NE, Higgins J, Ahmed S, Finch LE, Richards CL. Responsiveness and predictability of gait speed and other disability measures in acute stroke. Arch Phys Med Rehabil. 2001;82(9):1204-12.

14. Boza R, Duarte E, Belmonte R, Marco E, Muniesa JM, Tejero M, et al. Estudio baropodométrico en el hemipléjico vascular: relación con la discapacidad, equilibrio y capacidad de marcha. Rehabilitación. 2007;41(1):3.

15. Kluding PM, Dunning K, O'Dell MW, Wu SS, Ginosian J, Feld J, et al. Foot drop stimulation versus ankle foot orthosis after stroke: 30-week outcomes. Stroke. 2013;44(6):1660-9.

16. Miller L, Rafferty D, Paul L, Mattison P. A comparison of the orthotic effect of the Odstock Dropped Foot Stimulator and the Walkaide functional electrical stimulation systems on energy cost and speed of walking in Multiple Sclerosis. Disabil Rehabil Assist Technol. 2014.

17. Sabut SK, Lenka PK, Kumar R, Mahadevappa M. Effect of functional electrical stimulation on the effort and walking speed, surface electromyography activity, and metabolic responses in stroke subjects. J Electromyogr Kinesiol. 2010;20(6):1170-7.

18. Yamaguchi T, Tanabe S, Muraoka Y, Masakado Y, Kimura A, Tsuji T, et al. Immediate effects of electrical stimulation combined with passive locomotion-like movement on gait velocity and spasticity in persons with hemiparetic stroke: a randomized controlled study. Clin Rehabil. 2012;26(7):619-28.

19. Valentini FA, Granger B, Hennebelle DS, Eythrib N, Robain G. Repeatability and variability of baropodometric and spatio-temporal gait parameters--results in healthy subjects and in stroke patients. Neurophysiol Clin. 2011;41(4):181-9.

20. Menezes LTd, Barbosa PHFA, Costa AS, Mundim AC, Ramos GC, Paz CCSC, et al. Baropodometric technology used to analyze types of weight-bearing during hemiparetic upright position. Fisioter mov 2012;25(3):583-94.

21. Burridge JH, McLellan DL. Relation between abnormal patterns of muscle activation and response to common

peroneal nerve stimulation in hemiplegia. J Neurol Neurosurg Psychiatry. 2000;69(3):353-61.

22. Jang GU, Kweon MG, Park S, Kim JY, Park JW. A study of structural foot deformity in stroke patients. J Phys Ther Sci. 2015;27(1):191-4.

23. van Swigchem R, Weerdesteyn V, van Duijnhoven HJ, den Boer J, Beems T, Geurts AC. Near-normal gait pattern with peroneal electrical stimulation as a neuroprosthesis in the chronic phase of stroke: a case report. Arch Phys Med Rehabil. 2011;92(2):320-4.

24. Wilkinson IA, Burridge J, Strike P, Taylor P. A randomised controlled trial of integrated electrical stimulation and physiotherapy to improve mobility for people less than 6 months post stroke. Disabil Rehabil Assist Technol. 2014:1-7.