

## Physiotherapy on Gait Re-education in Adult Patients after Suffering a Cerebrovascular Accident with the Purpose to Obtain a Functional Gait

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### Abstract

**Introduction:** Re-education physiotherapy on gait disorders is essential to reintegrate patients, who suffered a Cerebrovascular Accident (CVA), in the activities of daily living. The first objective was to perform a review of the main methods of Physiotherapy intervention for gait's alterations in the Cerebrovascular Accident (CVA).

**Development:** Literature searches were made in these databases: Medline (Ovid), Pedro, SCOPUS, PsycINFO, Web of knowledge, CINAHL (EBSCOHost), SportDiscus (EBSCOHost), DOAJ, Cochrane, EMBASE, Academic Search Complete (EBSCOHost), Fuente Académica (EBSCOHost), and MedicLatina (EBSCOHost). A retrospective search of 5 years was used until April 2014. 33 records were selected based on the affinity with the subject of the review and their internal validity according to the PEDro scale.

**Conclusions:** Treadmill was followed by robots and electromechanical devices in the most cited method by the authors. We recommend further research on vibration therapy.

**Keywords:** ; Physiotherapy; Walking

### Introduction

The gait is a complex and integrated body movement. Moreover, it is very important to perform the activities of daily living. Walking functional performance and requires the interplay of multiple processes at the motor as dependent on many perceptual and higher centers [1].

After suffering a stroke a disruption occurs in our central control postural and motor integrated scheme that had altered. In addition, synergies and alterations appear tone and reciprocal innervation of certain muscle groups occur. All these factors lead to an abnormal gait [1-3].

The physiotherapist could confirm that walk again is one of the most important goals after stroke and in turn, one of the most desired by patients. One of the major purposes of physiotherapy are the following: achieving safe walking, automatic, rhythmic, harmonious, stylish gait, that does not require too much effort to move from one place to another, functional, autonomous, requiring at least possible assistive [1].

The main aim of this study is to detect the level of evidence and grades of recommendation regarding Physiotherapy in gait disturbances in patients after suffering a Stroke. Comparisons between the different methods of intervention in Physiotherapy in Stroke on a literature review with a retrospective five-year search.

### Methods

#### Literature search

A literature search was carried out to identify all possible studies that could help to answer the research question. The following databases were searched for relevant studies: Medline (Ovid), Pedro, SCOPUS, PsycINFO, Web of Knowledge, CINAHL (EBSCOHost), SportDiscus (EBSCOHost), DOAJ, Cochrane, EMBASE, Academic Search Complete (EBSCOHost), Fuente Académica (EBSCOHost), and MedicLatina (EBSCOHost). In addition to this, a manual search of the revised reference lists of identified articles and published conference abstracts were done by the reviewer.

Two reviewers carried out several searches in the databases using combinations of key words: Cerebrovascular Accident (CVA), ictus, Hemipleg\*, rehabilitation, Physical therap\*, step and gait. The searches were limited to English studies reported in between 2008 and April 2014. The randomized and not randomized trials, quasi-experimental trials, case studies and systematic reviews were included.

#### Inclusion and Exclusion Criteria

Inclusion criteria were constructed using the PICO (population, intervention, control/comparison and outcomes) model. First, the population included samples of adult patients who have suffered a Stroke in the acute phase [4] and after more than six month in the chronic phase [5]. Also, Patients are between four and six Brunnstrom's stage 6. The stages of Brunnstrom in hemiplegic patients range from [1-6]. Stage 1: No movement. Stage 2: Synergy movements associated with weakness. Stage 3: All movements are in synergy. Stage

4: Some deviations from synergies. Stage 5: Almost no synergy. Stage 6: Without synergy but patients are slightly clumsy [6].

Second, the intervention included gait training compared to different intervention methods in physiotherapy for gait training in stroke. Third, different types of randomized, non-randomized, cohort, quasi-experimental, systematic reviews and case studies were included.

Finally, the outcomes included were functional outcomes: spatial and temporal gait parameters [6-8], walking independently [9-12], functional balance [5], self-perception of motion [5], quality of life [5], reeducation and proprioception gait [10,13], functional walking ability [14-16], coordination of gait [17].

Physical capacity: step length [6,18-20], walking speed [4,5,6,8,18-26] distribution of body weight [20,21,27-29] walking resistance [5] maximum walking speed [5,30] walking distance [4,31] reduction in spasticity [7,25] energy expenditure during walking [7,24,26] ankle dorsiflexion 18 walking rhythm [8] symmetry between both lower limbs [32].

Clinical outcomes: up-and-go test [8,22,30,33] 6-Minute Walk Test [22,23,34,35] 10-m walk test [33-35], Berg balance scale [8,20,34] and Chedoke-McMaster Stages of Recovery for motor impairment in the foot and leg [34], 8-m walk test [36], 3-minute walk test [36], Tinetti balance test [36] and functional ambulatory capacity score [16].

Studies were excluded if they dealt with other CVA problems not related with gait alterations and minor age patients.

### Assessment of the Methodological Quality

Fifty-one relevant articles were found in the main databases. Thirty-three original studies were examined after subsequent selection based on the title and abstract. After analyzing the primary documents thirty-three were relevant to this review as were three systematic reviews.

The methodological quality of the twelve studies was evaluated using the PEDro scale [37-39]. Two independent reviewers (Palma-Jiménez, M. & Martín-Valero, R.) completed the assessment list based on PEDro score. This scale (0 to 10) is based on the list developed by Verhagen et al., [40] and assesses the internal validity of randomized controlled trials. A study with a PEDro score of 6 or more is considered level-1 evidence (6-8: good; 9-10: excellent) and a score of 5 or less is considered level-2 evidence (4-5: fair; <4: poor) [41].

### Results

Here are expressed the main results shown separately by methods/procedures Physiotherapy intervention. Characteristics of the selected studies are in Table 1.

Author	Journal	Number individuals	of	Kind of research	Intervention methods	PEDro Scale	Grade evidence	of
Kuys et al.4 -2011	Clin. Rehabil.	28		Double-blind randomized controlled trial	Treadmill with total body weight support	10-Aug	A	
Globas et al.5 -2012	Neurorehabil. Neural Repair.	38		Randomized Controlled Trial	Aerobic treadmill training	10-Jul	A	
Langhammer Stanghelle.6 -2010	Clin.Rehabil.	39		Randomized Controlled Trial	Treadmill training	10-Aug	A	
Cheng et al.7 -2010	Arch. Phys. Med. Rehabil.	15		Randomized Controlled Trial	Functional Electrical Stimulation and active ankle dorsiflexion	10-Jun	A	
Cho KH et al.8 -2013	Am J Phys Med Rehabil Assoc Acad Physiatr	14		Pilot Study	Gait training with virtual reality	10-Jul	B	
Ada et al.9 -2010	Stroke J. Cereb. Circ.	126		Double-blind randomized trial	Treadmill with partial body weight support	10-Aug	A	
Dean et al.10 -2010	J. Physiother.	126		Randomized double-blind trial	Treadmill with partial body weight support	10-Aug	A	
Mehrholz y Pohl.11 -2012	J. Rehabil.Med.	885		Systematic review	Gait electromechanical training robotic assisted		A	
Ada et al.12 -2011	J. Physiother.	549		Systematic review of meta-analysis of randomized trials	Walking mechanically assisted with body weight support.		A	
Bayón et al.13 -2009	Rehabil. Rev. Soc. Española Rehabil. Med. Física.			Review	Gait training with virtual reality		A	
Duncan et al.14	N. Engl. J. Med.	408		Blind, randomized and controlled trial.	Treadmill with partial body weight support	10-Jul	A	

-2011						
Koopman et al.15 -2013	J. Neuroengineering Rehabil.	18	Pilot Study	Assisted gait training by exoskeleton	10-May	B
Schwartz et al.16 -2009	PM R.	67	Prospective, randomized, controlled study	Device-assisted gait training robot	10-Jun	B
Hollands et al.17 -2012	Gait Posture	485	Systematic review	Treadmill, ankle-foot orthosis and functional electrical stimulation		A
Paoloni et al.18 -2010	Neurorehabil. Neural Repair.	44	Randomized Controlled Trial	Segmental muscle vibration	10-Aug	A
Hwang et al.19 -2010	Clin. Rehabil.	24	Controlled trial	Motor imagery practice	10-May	B
Sungkarat et al.20 -2011	Clin. Rehabil.	35	Randomized controlled trial with blinded assessor	External feedback with wedge insole in the shoe and pressure sensor	10-Jul	A
Franceschini et al.21 -2009	Stroke J. Cereb. Circ.	97	Blind randomized controlled trial	Treadmill with partial body weight support	10-Jun	A
Kang et al.22 -2012	Clin.Rehabil.	30	Randomized Controlled Trial	Treadmill with optic flow	10-Jul	A
Luft et al.23 -2008	Stroke J. Cereb. Circ.	71	Randomized Controlled Trial	Treadmill with total body weight support	10-May	A
Erel et al.24 -2011	Clin. Rehabil.	28	Randomized Controlled Trial	Dynamic ankle foot orthosis	10-Jun	A
Sêze et al.25 -2011	Clin. Rehabil.	28	Multicenter randomized Trial	Ankle Foot Orthosis	10-Jun	B
Polese et al.26 -2012	Clin. Biomech. Bristol Avon	19	Pilot Study	Walking with sticks	10-May	B
Iosa et al.27 -2011	J. Rehabil. Res. Dev.	20	Systematic study	Walking assisted with driving electromechanical	10-May	B
Kunkel et al.28 -2013	Neuromodulation Technol. Neural Interface.	21	Randomized Controlled Trial	Functional Electrical Stimulation and balance exercises and weight transfer	10-Jun	A
Guillebastre et al.29 -2012	Neurorehabil. Neural Repair.	92	Predictive Analytics study	Walking with sticks	10-May	B
Tanaka et al.30 -2012	Clin. Rehabil.	12	Pilot Study	Rehabilitation of walking with interface device type footpad	10-May	B
Hesse et al.31 -2012	J. Rehabil. Res. Dev.	30	Pilot Study	Waking assisted with robot	10-May	B
Muto et al.32 -2012	J. Neuroengineering Rehabil.	16	Pilot Study	Device adapted to lower limbs with auditory stimulus	10-May	B
Chan et al.33 -2012	Clin. Rehabil.	30	Randomized Controlled Trial	muscle vibration	10-Aug	A
Mackay-Lyons et al.34	Neurorehabil Neural Repair	50	Randomized Controlled Trial	Treadmill with body weight support	10-Aug	A

-2013						
Carda et al.35 -2012	Phys. Ther.	62	Randomized prospective trial	Hip Orthosis	10-May	B
Fisher et al.36 -2011	Top. Stroke Rehabil.	20	Pilot Study	Assisted gait training with robot on treadmill	10-May	B

**Table 1:** Characteristics of the selected studies.

## Treadmill

Langhammer et al. [6] obtained results of improvement in spatial and temporal gait characteristics with treadmill training. Also, speed and bilateral step length were increased during walking on the floor.

Ada et al. [9] indicated that 37% of subjects could walk independently in a month, 55% in two month and 71% in six month.

Franceschini et al. [21] used a body weight suspension system of a maximum of 40% body weight support. Walking speed improved from initials 0.09-0 '19 m/s to 0.2-0.4 m/s at the end of treatment. Suspension body weight decreased from initial 35'4 to 10-11 '8%

Globas et al. [5] had improvements in walking resistance, maximum walking speed, functional balance, self-perception of motion and quality of life.

Kang et al. [25] obtained an increase between 4'04-5'55 seconds in up-and-go test. 6-Minute Walk Test increased from 11 to 24.49 meters. Also, step velocity increased between 0.06 and 0.21 m/s.

Dean et al. [10] obtained good results in reeducation and proprioception gait. At six months 71% of patients could walk independently.

Duncan et al. [14] indicated that 52% of subject's increased functional walking ability.

Kuys et al. [4] indicated that at the 6th week walking distance was increased in 62 meters and walking speed was increased in 0'18 m/s.

Hollands et al. [16] indicated that treadmill training can provide a repetitive practice of gait pattern in the affected limb it cause a sensory and motive normalization, and an improvement on coordination of gait.

Luft et al. [23] enunciated that walking speed increased in 51% and 6-minute walk test improved in 19%.

Mackay-Lyons M et al. [34] obtained improvements with training treadmill with bodyweight support to measure 6-minute walk test, Chedoke-McMaster Stages of Recovery for motor impairment in the foot and leg, 10-m walk test and Berg balance scale.

## Functional Electrical Stimulation

Cheng et al. [7] obtained reduction in the spasticity of ankle, also spatial symmetry was increased and patients had less energy expenditure during walking.

Kunkel et al. [28] at 4 weeks patients obtained improvements on body weight support in a more equitable way in both lower limbs in a 44% and patients improved weight transfer on affected lower limb in 85'2%.

## Orthosis

Hollands et al. [17] indicated that interventions with ankle foot orthosis and functional electrical stimulation were beneficial for improving gait coordination.

Erel et al. [24] after three months patients had improvements in walking speed and the energy cost of gait was reduced.

Seze et al. [25] significant improvements were obtained in spasticity, walking speed and kinematic gait.

Carda et al. [35] indicated that patients had improvements on 6-minute walk test and 10-m walk test.

## Vibration Therapy

Chan et al. [33] obtained good results in the speed of testing up to ten meters and up-and-go test.

Paoloni et al. [18] obtained improvements on walking speed, step length bilaterally, the toe-off and a significant increase in ankle dorsiflexion in both lowers limbs.

### Canes

Polese et al. [26] indicated increment on walking speed and energy generation on ankle plantar flexors, knee extensors, and hip flexors of hemiplegic side.

Guillebastre et al. [29] the authors suggested that patients who don't load more than 40% of body weight in hemiplegic lower limb may benefit from using a cane.

## Robots and Electromechanical Devices

Fisher [36] obtained significant improvements on 8-m walk test, 3-minute walk test and Tinetti balance test.

Hesse [31] indicated that walking distance with the robot increased in 84'2-193'7 meters and walking distance on the floor increased in 52'9-86'4 meters between 3-4 weeks.

Koopman [15] most of patients increased their involvement and they could use visual feedback.

Schwartz et al. [16] obtained improvement on walking ability by an independent way according to functional ambulatory capacity score.

Mehrholz J et al. [14] found significant results on independent walking with the use of end effector in a group of subjects compared with another group in which an exoskeleton was used: 286 of 457 patients, 62.6%, versus 78 of 428 patients, 18.2%.

Iosa et al. [30] the ability of body weight supporting was increasing slowly, while walking speed increased rapidly in most affected patients. A reverse trend was observed on the least affected subjects.

Ada et al. [15] observed that greater number of patients could walk independently with mechanically assisted walking with body weight support at 4 weeks compared with assisted walking training on the floor.

### Imaginary practice

Hwang et al. [19] realized that walking speed increased 0.07-0.06 m/s. Step length increased 0'09-0'12 m on affected lower limb and step length increased 0'07-0'10 m on less affected lower limb.

### Feedback devices for foot

Tanaka et al. [33] had improvement on maximum walking speed in 16'6% and they had improvement on up and go test in 8'3%.

Sungkarat et al. [23] showed improvements on symmetry distribution of body weight, walking speed and step length. Patients had a mean improvement in 9'47 points on the Berg Balance Scale.

Muto et al. [35] observed significant improvements on asymmetry decrease between both lower limbs, but this decrease wasn't been maintained on the time.

### Virtual reality

Bayon, Martinez [13] reported that immersive virtual training improves gait versus non-immersive virtual training.

Cho et al. [8] used a virtual reality program with some recordings of gait on the real world. Authors obtained significant results ( $p < 0.05$ ) on the experimental group on Berg Balance scale (4.14), Timed Up and Go test (-2.25), spatiotemporal gait parameters, velocity and walking rhythm.

### Discussion

Ada et al. [9], Kang et al. [22] and Mackay-Lyons et al. [34] had better outcomes on treadmill interventions compared with training on the ground. However, Franceschini et al. [21] and Dean et al. [10] carried out a comparative study of gait treadmill training and walking on the floor. Franceschini et al. [21] indicated improvements in both groups before, during and after treatment and follow. In spite of that, Dean et al. [10] showed that in patients, who could walk independently, there wasn't any difference between both groups in stride length and speed. However, Duncan et al. [14] they had a higher sample than the rest of the studies which treadmill training was used. Treadmill training with body weight support was compared with an exercise program at home managed by a physical therapist in patients who have suffered a CVA in the last two and six month. All groups had similar improvements in walking speed, motor recovery, balance, functional state and quality of life [14].

Regarding intensity on treadmill training, Kuys et al. [4] applied high intensive to training treadmill in individuals with acute phase after stroke and they had good results in walking speed. Also, Globas et al. [5] implemented treadmill training in a high intensive, although patients had suffered a CVA more than six month ago and they had a light chronic disability. However, Franceschini et al. [21] indicated in

2009 that there wasn't any agreement on the intensity, frequency and duration of gait training on treadmill.

With regard to neuronal plasticity, Hollands et al. [17] indicated that in some studies there were quantified neuroplastic changes, which were associated with physiotherapy interventions in treadmill training to reeducate gait. Also, Luft et al. [23] declared that exercise on treadmill recruited circuits in the cerebellum; this reflected the plasticity of the neural network. This neuronal recruitment was associated to improvements in gait. No author indicated adverse effects of treadmill.

These authors [10,14,21] had similar results when they compared the effects of treadmill training with training on the floor or training at home. Also, they had higher sample than other authors [9,22] which results on treadmill training were better than the control group. This seems to show that treadmill is beneficial to reeducate gait in a high intensive [5].

Relative to functional electrical stimulation as Physiotherapy intervention method, some authors [7,28] obtained beneficial results.

The author [24,25] had good results with ankle foot orthosis. Erel et al. [24] and Carda et al. [35] indicated better improvements in studies with Ankle Foot Orthosis than studies without ankle foot orthosis in the physical therapist intervention. Hollands et al. [17] in their review recommend the use of ankle foot orthosis as the use of functional electrical stimulation. In spite of that, Seze et al. [25] recommend Hip Flexion Orthosis to improve hip flexion during walking.

Chan et al. [33] compared the effects of vibration on the whole body in an experimental group and in a control group which follow the same process but the vibratory machine was turned off. The sample which the vibratory session was applied was very small, only there were 15 patients. Also, authors compared the effects of only one session. So, we could indicate that bigger samples are needed and a large application of this therapy to have results more completed. However, Paoloni et al. [18] applied 12 sessions of segmental vibration therapy. This sample was higher than the sample of Chan et al. [33] and a major number of sessions was applied. In spite of that, authors showed different effects respect to vibration therapy. On the one hand, Chan et al. [33] explicated that when vibration therapy was applied in whole the body, the spasticity was smaller in plantar flexors. On the other hand, Paoloni et al. [18] indicated that when vibration therapy was applied in a segmentary way on the dorsiflexor muscles in the ankle, dorsal flexion was increased, but also the plantar flexion was increased during the swing phase of gait. So, we could suggest in the future major number of studies of this kind of therapy with larger samples, more number of sessions and these sessions can be applied by a segmental or global way to have more enlightening results.

With regard to the use of canes, Polese et al. [26] had improvements on the gait and they didn't indicated adverse effects. Also, Guillebastre et al. [29] recommend the use of cane on patients who didn't load more than 40% of their body weight in the hemiplegic lower limb. However, Polese et al. [26] applied their study to patients who the majority of them had a satisfactory walking speed. So, in this case, the improvement that they had when the patients used the cane couldn't be enough clear because there were patients in the sample who had few problems to walk and perhaps their body weight support could be higher to 40% in the hemiplegic lower limb.

Robotic devices to assisted walking are becoming on a popular alternative to gait reeducation [36]. The authors Hesse et al. [31]

Koopman et al. [15] Schwartz et al. [16] realized an assisted gait training with robot followed by a physical therapy reeducation walking program by a manual way. The authors had better results in the experimental group than the control group who hadn't been intervened with robotic devices. That suggests us that the addition of the robot to the Physical Therapy program had beneficial effects. Koopman et al. [15] used an exoskeleton in healthy patients and in patients who had suffered a CVA. There were [12] healthy patients compared with 6 patients with CVA. So, the sample of patients with CVA was smaller, also this sample didn't follow a proportion respect the number of healthy patients. Furthermore, Mehrholz et al. [11] had better results with an end effector than results with exoskeletons.

Relative to bodyweight support systems with electromechanical devices Iosa et al. [27] used a suspended harness system bigger than Carr and Shepherd 2 used which had to be minor than 30% body weight support.

Referring to auditory stimuli, Muto et al. [32] had beneficial effects in an experimental group with a feedback device to the lower limbs with auditory stimuli when the experimental group was compared with a control group. Also, Sungkarat et al. [20] realized that their results showed beneficial effects in the application of auditory feedback during gait reeducation. Tanaka et al. [30] indicated that an uniform repetitive movement could be useful to patients with chronic CVA. Also, Hollands et al. [17] said that repetitive intervention which was implemented in the specific practice of a task seemed to have promising approaches to restore coordination of gait.

Bayon et al. [13] indicated on their review that immersive systems were the best indicated to reeducate gait after a CVA. Also, Cho KH et al. [8] used an immersive virtual reality system for gait training after CVA and patients had significant improvements  $p < 0.05$ .

## Conclusions

Treadmill is an effective method for gait training in patients in acute and chronic phase after stroke. Functional electrical stimulation on the plantar flexors and dorsiflexors muscles and peroneal nerve, through a frequency of 30-40 Hz, with a pulse width between 100-300 microseconds and with impulse train may improve gait after CVA. Ankle foot orthosis and hip flexion orthosis correct walking in a stroke. Segmental and global vibration therapy appears to have beneficial effects although larger samples are needed. Moreover, more research in this type of therapy is needed to determine the effectiveness. Using canes seems not to have adverse effects on walking. Besides that, authors recommend the use of canes when less than 40% of the most affected lower limb. Electromechanical devices and robotic-assisted gait training can improve walking ability after stroke. Suspension body weight systems around 30% of body weight are beneficial for gait training in electromechanical devices, treadmill, robots and on the ground. Feedback systems with auditory stimulus have good results in gait training. Virtual reality can be used for gait reeducation and immersive systems are the most effective in this kind of therapy.

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