

The effect of gait training and exercise programs on gait and balance in post-stroke patients

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The aim of this review is to evaluate studies about gait training and exercise interventions applied to patients following chronic stroke on gait and balance. The studies included in this review were random clinical trials, including only chronic post-stroke individuals that evaluated gait and balance outcomes and with a PEDro scale score ≥ 7.0 . Eight studies were selected. The results suggest gait and balance will only be affected in chronic post-stroke patients if training sessions last at least 30 minutes, are repeated three times a week, and maintained for at least five weeks. Gait training affects how chronic post-stroke individuals walk. They will probably walk faster and with a lower risk of falling; however, it is unclear whether the consequences of these procedures affect the quality of life.

KEYWORDS: Stroke, Locomotion, Balance.

Mochizuki L, Bigongiari A, Franciulli PM, Francica JV, Alonso AC, Ervilha UF, Kiyomoto HD, Greve JMD. The effect of gait training and exercise programs on gait and balance in post-stroke patients. *MedicalExpress* (São Paulo, online). 2015;2(4)M150401.

Received for Publication on May 26, 2015; First review on June 28, 2015; Accepted for publication on July 6, 2015

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INTRODUCTION

Stroke is one of most common causes of death, worldwide.¹ It entails several clinical consequences: (a), physical (limb plegia or paresis, spasticity, stiffness, coordination and balance disorders, tremors, gross and fine motor ability deficits, sensory deficits, etc.); (b), behavioral (depression, anxiety, aggressiveness) and (c), cognitive (memory disorders, attention deficits, language disorders, planning actions disorders and perceptual deficits).

The decrease in functional capacity after a stroke is due to neuronal death and communication gaps between the central nervous system and its effectors (e.g. muscles).² Some of the acute limitations are walking³⁻⁸ and postural deficits.⁹⁻¹² These seriously affect daily life activities, curtailing independence and impoverishing social life.

Weakness in post-stroke persons may be either the consequence of neurological impairments or of

sedentary lifestyle. Post-stroke people who perform aerobic swimming pool training¹³⁻¹⁵ and/or treadmill walking^{16,17} increase their scores in the Timed-up-and-go test, in the Berg test and change their gait kinematics. Therefore, simple walking training programs increase not only aerobic capacity, but muscle strength and power, which are necessary for balance.¹⁶⁻¹⁸

How should gait training protocols for chronic post-stroke people be planned and executed? How many times per week? How long should they walk? The aim of this review is to describe and analyze selected clinical trials that evaluated the effect of gait training in chronic post-stroke individuals, in order to describe the volume (time and intensity) of gait training required to improve walking and balance in chronic stroke people.

METHOD

Bibliographic Research. We used the following databases: PubMed, EBM - Evidence-Based Medicine, ERL - Electronic Reference Library, ProQuest Dissertations & Theses, PSICODOC, Web of Science, Physical Education Index, Social Services Abstracts, Biological Abstracts,

DOI: 10.5935/MedicalExpress.2015.04.01

EBSCO, SCIELO and Lilacs. These databases were accessed in March 2014 and the search was not limited by publication date. The key words were related to the descriptors that were best related to encephalic vascular disease, stroke, balance and locomotion.

Only controlled clinical trials were selected. The filters employed for the bibliographic research were: ("Stroke/diagnosis"[MeSH] or "Stroke/rehabilitation" or Stroke"[Mesh] or "Infarction, Posterior Cerebral Artery"[Mesh] or "Infarction, Middle Cerebral Artery"[Mesh] or "Infarction, Anterior Cerebral Artery"[Mesh]) and ("Physical Therapy Modalities"[Mesh] or "Electric Stimulation Therapy"[MeSH] or "Exercise Movement Techniques"[Mesh] or "Postoperative Care"[Mesh] or "Complementary Therapies"[Mesh] or "Bobath"[All Fields] or "Physical Therapy Modalities/instrumentation" [All Fields] or "Gait"[Mesh] or "Stroke/rehabilitation"[All Fields] or "Stroke/therapy"[MeSH] or "Paresis/rehabilitation"[All Fields] or "Orthotic Devices"[All Fields] or "Paralysis/rehabilitation"[All Fields] not "Robots"[All Fields]) and ("Gait Disorders, Neurologic/rehabilitation"[MeSH] or "Musculoskeletal Equilibrium"[Mesh] or "Walking"[All Fields]) and ((Meta-Analysis or Randomized Controlled Trial or Review)). The inclusion criteria were: 1) study: clinical trial; 2) intervention: exercise or physical activity based therapy; 3) task: locomotion; 4) sample: participants should have had the stroke at least three months before intervention; and 5) study quality: PEDro scale score \geq 7.0. The exclusion criteria: 2) non clinical trial; 3) robot or electrical stimulation based training; 4) acute stroke patients (less than three months between stroke and training);

The tests for quality of life, cognitive, motor, and functional status, the protocols and equipment, and their results were searched for and described for every selected study. The intervention protocols (equipment, number of sessions, session duration, walking distance and velocity) were recorded. We also performed a manual search for studies in Conference Proceedings, doctoral thesis and master dissertations.

■ RESULTS

Initially, 85 articles were found. Thirty-four articles were excluded because they were not clinical trials. From the 51 clinical trials, 17 robot or electrical stimulation based training studies were likewise excluded. Studies with acute stroke patients and studies without information about the type of participants (acute or chronic post-stroke condition) were excluded. The PEDro (Physiotherapy evidence database) scale score of the eighteen remaining clinical trials was evaluated and eight studies¹⁹⁻²⁶ presented scores \geq 7.0; Table 1 provides the general characteristics of these studies.

Gait training was performed with weight support,¹⁹ progressive load,²⁰ in a virtual environmental,²¹ with visual feedback,²² with electromyography (EMG) feedback²³ and with mental training.²⁴

For gait training, the median duration of the session was 30 min, ranging from 15 to 55 minutes long; the median number of sessions per week was three, ranging from two to five; the median number of weeks of training was four, ranging from three to ten. Thus, the median total number of sessions of gait training was 15, ranging from 12 to 20. Such a number of sessions can be reached if someone walks 3 days/week for five weeks.

Gait training affected balance control. Choo & Lee²¹ report that gait training increased the Berg test score. Subjects were reported to increase their score in functional reach tests after gait training.²² Three studies claim that gait training decreased the time for the Timed-up-and-go test.²⁰⁻²²

Gait training improved gait. Six studies showed that factors that increase gait velocity increased after gait training resulting in (a) faster walking,^{19,21-23} (b) higher stride frequency²¹ and (c) and increased stride length.²³ Three other reports showed changes related to walking, namely mobility,²⁵ muscle strength²⁰ and home walking.²⁴

Choo e Lee²¹ compared gait training on a treadmill and gait training while watching a movie simulation of real environments (street walking on a sunny or on a rainy day, street walking with obstacles, walking around at home during the day or at night, and hiking) for 30 min. Those movies were not synchronized with the treadmill belt speed. Both groups had standard therapy (physical and occupational therapy) and gait training. Training was performed three times per week for six weeks. Gait velocity was self-selected. Performance in the Berg test, in the Timed-up-and-go test, in walking (gait velocity, stride frequency and length, and stance time of the paretic limb) were similar between groups. However, when compared to the control group, training with virtual reality increased Berg and Timed-up-and-go test scores, gait speed, and stride frequency.

Dickstein et al.²⁴ evaluated the effect of mental training upon gait performance. For the first four weeks, an experimental group performed the mental training, while the control did not. For the last four weeks, this procedure was reversed. The mental training sessions lasted 15 minutes, three times per week, for four weeks. This was performed at home with the assistance of a physical therapist. Mental images were suggested by the therapist to be created and focused on during nine minutes. Three minute relaxation intervals were allowed before and after the mental training. Participants were stimulated to think about images of walking outside and inside the home. The control group received physical therapy for the impaired limb, by means of upper limb exercises inspired in daily life activities (such as taking food to the mouth, wearing

Table 1 - Summary of selected articles in this literature review

Authors	Intervention	Session duration	Training frequency	Aparatus	Main outcomes
Cho and Lee ²¹	Virtual gait training	30 min	3 session/week for 6 weeks	Datashow projector, desktop, personal omputer, treadmill	Higher scores in Berg Balance Scale and Time Up and Go. Faster wakling, higher stride frequency and longer stride length.
Dickstein et al. ²⁴	Mental gait training	15 min	3 session/week for 4 weeks		Walking better at home.
Flansbjer et al. ²⁰	Progressive resistance training (80% of MVC)	20 min	2 session/week for 10 weeks	extensor bench	Stronger muscles, higher scores in walking, Time Up and Go. Better participation perception.
Green et al. ²⁵	Physical exercises in group	-	No information	Inquiry for mobility during daily life activities	Small increase in mobility index.
Jonsdottir et al. ²³	EMG Biofeedback for gait training	45 min	20 sessions	EMG system	Higher power during gait propulsion phase. Faster walking and longer stride length.
Mirelman et al. ²²	Simulation of walking on the street using virtual reality googles	30 min	3 session/week for 4 weeks	Treadmill and virtual reality googles	Higher scores in function reach test, Time Up and Go, 6 minutes walking test
Mudge et al. ²⁶	Circuit training for walking	-	12 sessions	Fake furniture	None changes in gait kinematics
Peurola et al. ¹⁹	Gait training with weight support	55 min	5 session/week for 3 weeks	Treadmill with weigth support system	Faster walking

gloves and object manipulation). Gait velocity at home increased after both interventions and the experimental group walked faster in the home than the control group; gait velocity outside home did not. The authors suggest that mental training added to gait training might improve walking in post-stroke persons.

Mirelman et al.²² showed the effects of gait training with a virtual reality helmet. Inside the helmet a simulated environment synchronized with the treadmill belt speed was projected. The control group received standard physical therapy. The interventions lasted 30 minutes, were applied three times per week for four weeks. Use of the virtual reality helmet presented the best results for the Timed-up-and-go test, for the ten-meter and for the six-minute walking tests. Gait training (with or without the helmet) increased functional reach test scores. Those results suggest that visual feedback is important to improve the results of gait training chronic post-stroke patients.

Jonsdottir et al.²³ showed the effects of lateral gastrocnemius muscle EMG biofeedback applied to gait training. They assigned 20 participants randomly to the EMG-BFB group or to a control group that received conventional therapy for the same duration. Treatment was administered with a fading frequency of biofeedback application and an increasing variability in gait activities. Both groups had 20 treatment sessions of 45 minutes

each, including at least 15 minutes of walking-related therapy for the control group. Follow-up tests were applied six weeks after the end of the interventions. Inverse dynamics using gait kinetics and kinematics analysis was performed to calculate the joint power. The EMG biofeedback group walked faster, with longer strides and presented higher ankle power during the propulsion phase of the gait. These results were still essentially the same at follow-up, six weeks later. They suggest that EMG biofeedback improves rehabilitation of stroke impairments.

Mudge et al.²⁶ evaluated whether circuit-based rehabilitation would increase the amount and rate that post-stroke individuals can walk in their usual environments. The exercise group had 12 sessions of clinic-based rehabilitation delivered in a circuit class designed to improve walking. The control group received a comparable duration of group social and educational classes. Circuit-based rehabilitation leads to improvements in gait endurance but does not change the amount or rate of walking performance in usual environments. Clinical gains made by the exercise group were lost 3 months later.

Green et al.²⁵ evaluated the effect of standard community physical therapy in chronic stroke people. The Rivermead mobility test score was higher for the

experimental group. This effect was not observed in the six and nine months follow-up checks. Community physical therapy did not affect daily life activities, social life, anxiety, depression, number of falls, or caregiver's emotional stress. Community physical therapy changes mobility, but clinical change in gait capacity increase was small and did not last for long.

Peurala et al.¹⁹ compared gait training on the ground and on a treadmill with weight support. The gait training session lasted 20 minutes, was applied for 15 sessions over three weeks. Both ground and treadmill groups received had standard physical therapy. Half of the patients in the treadmill group received functional electrical stimulation on leg muscles during gait training with weight support; the other half received no electrical stimulus. Similar results were observed for all gait-training subgroups after training and at a six-month follow-up. They walked faster with increased dynamic balance; their motor test skills performance improved.

■ CONCLUSIONS

Gait training mainly affects the walking parameters, increasing velocity,^{19,21-23} stride frequency²¹ and stride length,²³ with faster Timed-up-and-go test scores,²⁰⁻²² better mobility;²⁵ and stronger walk at home.²⁴ Gait training improves balance control. The risk of falls is reduced due to a better performance in the Berg test²¹ and in functional reach test.²² Therefore, gait training affects how chronic stroke people walk. They might walk faster and with a lower risk to fall; but it is unclear whether the consequences of this training affects quality of life.

The median results suggest that gait training for chronic stroke individuals should last at least 30 minutes, be repeated three times a week, and be continued for at least five weeks to affect gait and posture. Gait training should be performed at health centers, sport facilities or at any other place where a treadmill with a weight support is available. It is necessary to monitor heart frequency during the entire sessions for the prevention and immediate care of anomalous heart conditions.

It is not possible to conclusively define which gait training protocol is the best for chronic stroke persons, because the various studies reported here did not evaluate the similar outcomes: in most of the studies, participants walked on a treadmill; virtual reality, EMG biofeedback or weight support were successfully applied.

■ CONFLICT OF INTEREST

The author declare no conflict of interest regarding the publication of this review

■ AUTHOR PARTICIPATION

Bigongiari A, Franciulli PM, Francisca JV, Alonso AC, Ervilha UF, Kiyomoto HD provided substantial contributions to research conception reference research selection and discussion, and drafting of the article; Mochizuki L and Greve JMD critically revised the manuscript for essential intellectual content.

O EFEITO DO TREINAMENTO DE MARCHA E PROGRAMAS DE EXERCÍCIOS NA MARCHA E EQUILÍBRIO POSTURAL EM PACIENTES APÓS ACIDENTE VASCULAR ENCEFÁLICO CRÔNICO.

RESUMO: O objetivo desta revisão é avaliar estudos sobre intervenções com treino de marcha e exercícios específicos sobre marcha e equilíbrio postural, aplicados a pacientes após acidente vascular encefálico em fase crônica. Os estudos incluídos nesta revisão foram ensaios clínicos randomizados, incluindo apenas indivíduos pós-acidente vascular encefálico em fase crônica que avaliaram marcha e equilíbrio postural, com uma pontuação em escala PEDro ≥ 7.0 . Oito estudos foram selecionados. Os resultados sugerem que a marcha e o equilíbrio somente são afetados em pacientes crônicos pós-acidente vascular encefálico se as sessões de treinamento tiverem duração mínima de 30 minutos, forem repetidos três vezes por semana, e mantidos durante pelo menos cinco semanas. O treino de marcha e os exercícios afetam a forma como os indivíduos pós-acidente vascular encefálico em fase crônica andam. Eles provavelmente andarão mais rápido e com menor risco de quedas; no entanto, não está claro se as consequências destes procedimentos afetam a qualidade de vida.

PALAVRAS-CHAVE: Acidente vascular encefálico, equilíbrio postural e locomoção.

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