Gait & Posture 37 (2013) 627–630

Contents lists available at SciVerse ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short communication

Effects of a gait training session combined with a mass on the non-paretic lower limb on locomotion of hemiparetic patients: A randomized controlled clinical trial

C. Bonnyaud [a,c,*], D. Pradon [a], R. Zory [a], B. Bussel [b], D. Bensmail [b], N. Vuillerme [c,d], N. Roche [a]

[a] UVSQ, EA 4497, CIC-IT 805, APHP Physiology Department, Raymond Poincaré Hospital, Garches, France
[b] UVSQ, EA 4497, CIC-IT 805, APHP Neurorehabilitation Department, Raymond Poincaré Hospital, 92380 Garches, France
[c] Laboratoire AGIM, FRE 3405 CNRS/UJF Grenoble/UPMF/EPHE, France
[d] Institut Universitaire de France, 103, Boulevard Saint-Michel, 75005 Paris, France

ARTICLE INFO

Article history:
Received 11 April 2012
Received in revised form 31 August 2012
Accepted 13 September 2012

Keywords:
Hemiparesis
Gait analysis
Gait training
Rehabilitation
Restraint

ABSTRACT

Background: Results of recent studies have suggested that restraint of non-paretic lower limb movement could improve locomotion in hemiplegic patients. The aim of this study was therefore to determine if a mass applied to the non-paretic lower limb during a single gait training session (GTS) would specifically improve spatio-temporal, kinematic and kinetic gait parameters (GP) of the paretic lower limb.
Methods: Sixty chronic hemiplegic subjects were included in this randomized study. Each participated in one of four GTS conditions: overground or on a treadmill while wearing or not wearing an ankle mass. All subjects were assessed before, immediately after and 20 min after the end of the GTS using 3D gait analysis.
Results: The results showed that restraining the non-paretic lower limb during a GTS had no specific effect on GP of the paretic limb, whereas it increased braking force of the non-paretic limb.
Conclusion: Restraining the non-paretic lower limb of hemiparetic patients with a mass applied to the ankle does not seem to be an effective approach to improve paretic lower limb parameters during a single GTS.

1. Introduction

Recent studies suggest that, in hemiplegic patients, restraining lower limb movement could be a useful technique to improve locomotion [1,2]. Inspired from Taub's upper limb constraint induced technique [3], this technique consists of forcing use of the paretic lower limb by restraining the movement of the non-paretic lower limb. However, since complete immobilization of the non-paretic lower limb (as is carried out for the upper limb) is impossible during locomotion, a few studies have suggested a partial restraint of the non-paretic lower limb [1,2]. Regnaux et al. studied the effect of a single GTS on a treadmill with a mass attached to the non-paretic ankle in ten hemiplegic patients [2]. Their hypothesis was that the mass attached on the non-paretic ankle would partially restrain the movement of this lower limb and in consequence favor the use of the paretic lower limb. Their results showed that several kinetic and kinematic GP of the paretic lower limb were improved [2]. However, because of the design of the study it was not possible to determine (i) if improvements found were due to the mass; (ii) the treadmill or (iii) the combination of both the treadmill and the mass. In order to orientate rehabilitation techniques appropriately, it is important to study the specific effect of restraining non-paretic lower limb movement on the locomotion of hemiplegic patients more closely. The main aim of this study was thus to determine the specific effect of restraining the non-paretic lower limb during a GTS on gait parameters of the paretic lower limb. To that end, we performed a randomized controlled study (i) to determine, if a single GTS combined with a mass fixed to the non-paretic ankle induces specific changes of spatio-temporal, kinematic and kinetic GP of the paretic lower limb in hemiplegic subjects and (ii) to assess the effect on the non-paretic lower limb. The effect of restraining the non-paretic lower limb was assessed in two common gait training conditions used in clinical practice; overground and on a treadmill, in order to define an optimal restraining paradigm to improve locomotion of hemiplegic patients.

2. Methods

2.1. Subjects

Sixty hemiplegic subjects (50.3 years ± 13.1, 30 with right hemiparesis, 30 with left hemiparesis, 45 men and 15 women, mean time since stroke: 5.7 years ± 6.3) were

* Corresponding author at: UVSQ, EA 4497, CIC-IT 805, Raymond Poincaré Hospital, 92380 Garches, France. Tel.: +33 1 47 10 79 00x5025.
E-mail addresses: celine.bonnyaud@ens.uvsq.fr, c.bonnyaud@gmail.com (C. Bonnyaud).

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http://dx.doi.org/10.1016/j.gaitpost.2012.09.010

Table 1
Spatiotemporal gait parameters.

	Group	Baseline	Post0	Post20	p (time × mass)
Speed (cm/s)	GO	80.0 (19.7.0)	85.8 (22.1)	85.7 (20.7)	$p = 0.75$
	GOM	77.8 (22.8)	81.0 (28.3)	83.1 (27.9)	
	GT	83.3 (24.2)	86.2 (25.1)	87.0 (23.9)	$p = 0.60$
	GTM	84.7 (14.3)	89.5 (14.9)	89.8 (13.7)	
Cadence (step/min)	GO	90.4 (7.6)	92.9 (9.1)	92.4 (8.6)	$p = 0.66$
	GOM	88.42 (10.4)	91.7 (11.6)	93.0 (12.1)	
	GT	94.0 (15.6)	95.6 (14.7)	96.4 (15.3)	$p = 0.54$
	GTM	94.4 (8.4)	95.2 (9.0)	96.6 (8.2)	
Step length	GO	53.6 (8.2)	54.3 (8.0)	55.0 (7.6)	$p = 0.47$
Paretic side (cm)	GOM	53.1 (8.9)	53.9 (8.4)	56.2 (9.2)	
	GT	54.4 (9.8)	55.6 (8.0)	55.5 (9.3)	$p = 0.99$
	GTM	55.6 (5.9)	56.9 (5.9)	57.3 (5.8)	
Step length	GO	45.3 (12.0)	47.8 (10.4)	49.4 (12.3)	$p = 0.85$
Non-paretic side (cm)	GOM	46.3 (8.1)	48.9 (9.0)	49.3 (9.3)	
	GT	48.9 (9.4)	48.9 (8.5)	49.5 (9.8)	$p = 0.77$
	GTM	49.9 (8.9)	51.0 (11.3)	51.9 (8.9)	

GO, overground gait training (reference group for GOM); GOM, overground gait training with ankle mass; GT, treadmill gait training (reference group for GTM); GTM, treadmill gait training with ankle mass.

included. This study was performed in accordance with the ethical codes of the World Medical Association and was approved by the local ethics committee.

2.2. Experimental set up

After inclusion, patients were randomized to carry out one of four gait training conditions: overground without a mass (GO), overground with a mass (GOM), treadmill without a mass (GT), treadmill with a mass (GTM). GO and GT were therefore the reference groups for GOM and GTM respectively.

The GTS all lasted 20 min. Patients were instructed to walk without stopping, at their own comfortable speed. The mass fixed to the ankle of the non-paretic lower limb (for the GOM and GTM groups) was 2 kg for women and 4 kg for men as in the protocol by Regnaux et al. [2]. All gait analyses were carried out without the mass. There was no warm up period.

2.3. 3D gait analysis

Gait analyses were carried out (i) before the GTS (baseline), (ii) immediately after (Post0) and (iii) after a 20 min seated rest (Post20). Gait analysis was performed using a Motion Analysis System (100 Hz, Motion Analysis Corporation, CA, USA) and 2 AMTI force plates (1000 Hz, Advanced Mechanical Technologies Inc., Newton, MA, USA). The Helen Hayes marker set was used [4]. For both paretic and non-paretic lower limbs, three types of GP averaged over 10 gait cycles were analysed:

1. Spatiotemporal parameters: walking speed, cadence and step length.
2. Kinematic parameters: peak hip and knee flexion and peak ankle dorsiflexion.
3. Kinetic parameters: braking and propulsion force peaks and the vertical Ground Reaction Force (GRF) peak during total support phase.

Table 2
Kinematic gait parameters.

	Group	Baseline	Post0	Post20	p (time × mass)
Peak hip flexion	GO	35.5 (9.1)	36.5 (10.3)	36.1 (9.9)	$p = 0.61$
Paretic side (°)	GOM	32.0 (6.4)	32.4 (6.9)	32.0 (6.7)	
	GT	37.5 (9.3)	37.8 (9.3)	37.6 (9.5)	$p = 0.75$
	GTM	37.9 (7.9)	37.6 (8.6)	37.6 (8.7)	
Peak knee flexion	GO	42.6 (12.3)	42.6 (13.5)	41.9 (12.4)	$p = 0.54$
Paretic side (°)	GOM	38.8 (11.6)	38.8 (12.4)	39.2 (11.9)	
	GT	47.7 (8.6)	47.9 (9.7)	48.4 (9.2)	$p = 0.84$
	GTM	47.9 (8.9)	48.9 (8.9)	48.9 (8.9)	
Peak ankle dorsiflexion	GO	12.2 (5.9)	11.6 (5.6)	12.0 (5.4)	$p = 0.19$
Paretic side (°)	GOM	17.4 (5.7)	17.8 (5.8)	17.6 (5.8)	
	GT	15.3 (5.9)	14.7 (5.3)	17.8 (5.6)	$p = 0.35$
	GTM	18.6 (3.8)	18.8 (4.1)	18.8 (3.9)	
Peak hip flexion	GO	44.3 (7.4)	45.9 (7.9)	45.8 (8.1)	$p = 0.98$
Non-paretic side (°)	GOM	42.1 (6.7)	43.6 (6.4)	43.7 (6.5)	
	GT	42.7 (10.0)	43.5 (10.8)	43.4 (10.5)	$p = 0.61$
	GTM	42.9 (8.1)	43.4 (8.4)	42.8 (8.6)	
Peak knee flexion	GO	65.3 (9.0)	66.9 (8.44)	67.1 (8.4)	$p = 0.92$
Non-paretic side (°)	GOM	64.5 (7.2)	65.7 (6.1)	65.9 (5.8)	
	GT	64.4 (8.0)	64.7 (8.5)	64.8 (8.7)	$p = 0.84$
	GTM	67.4 (5.0)	67.9 (4.9)	67.7 (4.8)	
	GO	20.1 (5.0)	20.0 (4.0)	20.0 (3.6)	$p = 0.63$
Peak ankle dorsiflexion	GOM	23.5 (5.0)	23.3 (4.9)	22.7 (5.3)	
Non-paretic side (°)	GT	18.9 (4.3)	18.7 (4.3)	18.2 (4.6)	$p = 0.025$
	GTM	20.9 (3.6)	21.2 (3.6)	21.3 (3.7)	

GO, overground gait training (reference group for GOM); GOM, overground gait training with ankle mass; GT, treadmill gait training (reference group for GTM); GTM, treadmill gait training with ankle mass.