

Improving Gait and Balance in Multiple Sclerosis Using Partial Body Weight Supported Treadmill Training

Waleed T. Mansour¹, Azza M. Atya², Ahmed M. Aboumoussa³

Departments of Physical Therapy in Neuromuscular Disorders and Its Surgery¹, Basic Science², Faculty of Physical Therapy; Neurology³, Faculty of Medicine; Cairo University; Egypt

ABSTRACT

Background: The majority of patients with MS develop progressive gait impairment, which can start early in the disease and worsen over a lifetime. Providing a dynamic and task-specific approach such as partial body weight support training integrates essential components of gait and facilitates symmetrical gait patters. **Objective:** The aim of this study is to assess the changes in gait and balance displayed by MS patients after a whole task training of ambulation with body weight suspension on a treadmill. **Methods:** Twenty four patients with relapsing remitting multiple sclerosis who have cerebellopyramidal involvement participated in this study. Patients were assigned randomly into two equal groups (GI and GII). Subjects received rhythmical gait training. GI was treated over the treadmill only, while GII was treated by 40% body weight suspension (BWS). Patients were assessed clinically by Timed-get-up-and-go-test, Overall stability index and kinematically through motion analysis system by measuring stride length and cadence, before and after the last treatment session. **Results:** Patients who received partial body weight support training showed a statistically significant improvement in the different ambulation and kinematic parameter ($P < 0.05$). **Conclusion:** Partial body weight support training can be suggested as an effective way in rehabilitating gait and balance in MS patients. [Egypt J Neurol Psychiat Neurosurg. 2013; 50(3): 271-276]

Key Words: Multiple Sclerosis, Gait analysis, Balance, Treadmill, Body Weight Suspension.

INTRODUCTION

Multiple sclerosis is a progressive disease of the central nervous system (CNS) that cause widespread demyelination of the axons of sensory and motor neurons. The locomotion of the patients is often impaired by poor muscle activation, poor weight bearing capacities and poor balance. Recently Kaipust et al 2012 found that in patients with MS the natural fluctuations present during gait in the stride length and step width time series are more regular and repeatable. These changes implied that patients with MS may exhibit reduced capacity to adapt and respond to perturbations during gait.¹

El-Ghoneimy and colleagues in 2011 studied gait characteristics in patients with multiple sclerosis. They concluded that gait parameter evaluation in MS is necessary with respect to clinical type of MS to assess effect of medical treatment and follow up for rehabilitation protocols.²

Restoration of gait is a major goal in rehabilitation of MS patients. Modern concepts favor a task-specific, repetitive approach for walking training. Although there are many techniques available for treating gait deficits and motor impairment in MS patients, none of these techniques is sufficient to return those patients to a normal walking pattern.³

Correspondence to Ahmed Aboumoussa, department of Neurology Cairo University, Egypt.

Tel.: +201068884582 E-mail: abomosaa1@hotmail.com

Body Weight-Supported Treadmill Training (BWSTT) is a gait training strategy that involves the unloading of the lower extremities by supporting a percentage of body weight. The strategy utilizes suspension system to support a percentage of the patient's body weight as the patient walks on a treadmill. Additionally, BWSTT allows therapists to safely initiate gait training earlier in the rehabilitation process.⁴

Current studies demonstrate that the use of BWSTT leads to a better recovery of ambulation, with effects on over-ground walking speed, balance, and physical assistance required to walk.⁵ The purpose of this study was to assess the changes in gait and balance displayed by multiple sclerosis patients because of an intervention of whole task training of ambulation with body weight suspension on a treadmill.

SUBJECTS AND METHODS

The study was conducted upon 24 patients with multiple sclerosis. The diagnosis was based on the modified McDonalds criteria.⁶ We selected patients with cerebello-pyramidal involvement in the course of their illness. Inclusion criteria were (a) relapsing remitting type of MS, (b) patients should be at least in a remission for one month, (c) their weights ranged

from 60 to 90 kg, (d) Kurtzke's Expanded Disability Status Scale (EDSS) is equal or less than four, (e) absence of visual or mental affection that interfere with the methodology, (f) muscle tone is grade 2 according to modified Ashworth scale to avoid the impact of spasticity on the treadmill training, and (g) no history of hypertension.

All the patients were subjected to 1-Thorough history taking with stress on the occurrence of falls, coordination deficits and gait difficulties and complete neurological examination. 2-Assessment of the EDSS score. 3-Timed get-up and go test. This test was done to evaluate the effect the functional balance during gait. The patients was seated on a chair as a starting position, and then asked to stand up, walk 3 meters, turn around, return and sit down again. The total time was recorded to accomplish the task.⁷ 4-Overall stability index. Patients were encountered to the Biodex Stability System apparatus, to adjust the support handles and the visual screen display. Patients were instructed to stand up on the foot platform, grasp the support handles at the beginning of the test, and to leave it as the test proceeded. Test duration was set for 30 seconds for successive three trials at the level eight (the most stable level). The patients were asked to try to maintain a centered position on the platform once the platform was set in motion. This achieved through keeping the cursor on the visual feedback screen in the center.⁸ 5-Kinematics analysis. For measurement of the kinematic gait cycle parameters, the patients walked approximately six meters on walkway at their own comfortable speed. At least three walking trials were recorded for each patient by video-based motion analyzer. Walking over the walkway to measure kinematic data for determining stride length and cadence.⁹

All patients received their traditional physical therapy program (Proprioceptive Neuromuscular facilitation techniques, Frenkel coordination exercises and balance training). All subjects received gait training and the patients were assigned to develop two homogenous groups: group I received full body weight treadmill training and group II received treadmill training with 40% partial body weight support. The gait training includes 30 minutes (five m. training & five m. rest respectively), this means 15 minutes training and 15 minutes rest three days per week every other day for six weeks on a motor-driven treadmill with fixed speed control equals 2.25m/sec.

Materials

Opto-electronic Motion Analysis System (OEMAS); computerized gait analysis was performed for all patients, through a motion analysis system called Arial Performance Analysis System (APAS). This system included well positioned video cameras, a computer containing software for the collection and

analysis of data. The movement of the patient was recorded by six Panasonic video cameras placed in different planes. The cameras were positioned at right angles. The cameras worked at a sampling rate of 50 Hertz (Hz). Twenty passive markers were positioned over specific anatomical points of the trunk and lower limbs. The recording technique and the software allowed three-dimensional reconstruction of the motion in the major joints of lower extremities. The video records were used for kinematic gait assessment.^{10,11} Qualisys (Q) motion capture system consists of the following parts a-Pro Reflex MCU 120 (Motion – Capture Unit): It composed of six cameras, b-Wand-kit; its type is 130440, used for the calibration of the system, c-PC Computer with the Q-Trac and Q-Gait software installed, d-Skin markers; Twenty silver markers of eight centimeter square surface area were used. Markers were placed over 20 bony landmarks over the skin of the patient. The position of the skin markers were: on the shoulders, 12th thoracic vertebra, the anterior superior iliac spines, on the sacrum, the greater trochanter of the femur, the superior edge of the patella, the lateral knee joint line, tibial tuberosity, lateral malleolus, over each foot between the bases of the second and third metatarsal bones, each heel.⁵

Biodex Stability System; (Biodex corporation, Shirley, NY, USA) was used to assess Overall Stability Index (OSI) of the patients before and after treatment (the stability is believed to be the best indicator of the overall ability of the patients to balance performance), in which the larger the stability index value, the greater the degree of instability.¹²

Stop watch; was used to calculate time while the patients performing the Time get-up-and-go test.

We used treadmill 770 CE, 220 V, 50 Hz, 10 A, and 2.2 kilowatts (kw), that allows a person to exercise in a safe environment, with adequate space, and with simple fingertip control of all important parameters; including speed; aiming for motor rehabilitation.¹³

We also used Biodex Unweighting System; ETL listed to UL 2601 and ETL listed to CAN/CSA c22.2 No. 601.1-M90. Height: 270 cm. accommodates patients up to 210cm on a standard treadmill. It includes; spreader bar, harness vest, leg straps, display power and handrail. The safety harness vest fit properly over the patient. Leg straps provided additional security to maintain the vest in proper position. Because fitting the vest can be time consuming, it was suggested that, several vest sizes must be available to match various patient sizes.¹⁴

Statistical Analysis

SPSS (Statistical Package For The Social Science) software version 13.0 was used in the analysis of all obtained data. Statistical analysis was performed

with the use of parametric and non parametrical studies. P-value was considered significant if <0.05

RESULTS

General characteristics of the patients:

Demographic characteristics and clinical features of groups are shown in Table (1). There was no significant difference between groups in term of age and weight ($P>0.05$). The duration of the disease was less than 2 years in the two groups.

Comparative results: Timed get-up-and-go test:

Both groups showed an improvement after training yet patients with partial body weight support showed a statistically highly significant improvement in timed get-up and go test after treatment (Table 2).

Overall stability index: Patients with partial body weight support showed a statistically highly significant improvement in Overall Stability Index test after treatment (Table 3).

Stride length: Patients with partial body weight support showed a statistically highly significant improvement in Stride length after treatment (Table 4).

Cadence; Patients with partial body weight support showed a statistically highly significant improvement in Cadence after treatment (Table 5).

Angular motion of Ankle dorsiflexion during Initial contact improved in both groups without a statistically significant difference. Also during stance phase there was a statistically significant difference in trunk rotation. EDSS: the improved walking performance was not transferred into changes in overall disability, as measured using the EDSS.

Table 1: Demographic Data of 24 MS Patients.

Patient characteristics	G-I			G-II		
	Min	Max	Mean±SD	Min	Max	Mean±SD
Age (years)	37	48	41.67±3.65	33	47	40.42±4.1
Weight (kg)	65	88	75.26±6.8	60	87	74.8±7.27
EDSS score	2	4	2.8±.2	2	4	2.9±.3
Timed-get up and go test	12.5	18.5	16.32±1.55	14.2	17.6	16.20±0.97
Overall stability index	3.72	6.4	6.03±0.6	3.1	6.94	6.47±0.69
Cadence (Number of steps minute)	64.92	85.11	71.86±6.9	63.17	84.01	70.14±4.06
Stride length in meter	0.41	0.63	0.46±0.09	0.43	0.69	0.51±0.11

Table 2: Timed get-up-and-go pre- and post treatment of both groups I & II.

Group	Pre	Post	P-value
	Mean±SD	Mean±SD	
Group I	16.32±1.55	13.11±1.2	0.001*
Group II	16.20±0.97	11.80±0.93	0.000*
P-value	0.83	0.005*	

* Significant at $P<0.01$

Table 3: Overall Stability Index (OSI) pre- and post treatment of both groups I & II.

Group	Pre	Post	P-value
	Mean±SD	Mean±SD	
Group I	6.03±0.6	4.83±0.92	0.002*
Group II	6.47±0.69	3.80±0.86	0.000*
P-value	0.37	0.01*	

* Significant at $P<0.01$

Table 4: Stride length (SL) pre- and post treatment of both groups I & II.

Group	Pre	Post	P-value
	Mean±SD	Mean±SD	
Group I	0.46±0.09	0.54±0.14	0.026*
Group II	0.51±0.11	0.67±0.10	0.015*
P-value	0.074	0.037*	

* Significant at P<0.05

Table 5: Cadence pre- and post treatment of both groups I & II.

Group	Pre	Post	P-value
	Mean±SD	Mean±SD	
Group I	71.86±6.9	79.57±5.82	0.015*
Group II	70.14±4.06	83.7±3.02	0.000**
P-value	0.465	0.044*	

* Significant at P<0.05, ** Significant at P<0.01

DISCUSSION

The results of this study points towards a significant improvement in the kinematics of gait in patients treated with BWS training. Wier and colleagues 2011 mentioned that body-weight-supported treadmill training (BWS) enables individuals to walk on a treadmill while a portion of their body weight is supported. This system allows people with motor deficits that render them unable to completely support their own body weight to practice and experience locomotion at physiological speeds.¹⁵

Moreover patients with MS do have a complex form of disabilities interfering with their gait. In this study we found that BWS training was able to give the patients the opportunity to develop necessary initial locomotor coordination as a foundation of improving his gait hence reduce his overall disability.

Patients with partial body weight support showed a statistically highly significant improvement in Overall Stability Index test after treatment. Body weight supported treadmill training can probably affects and contributes to human postural control and also affect the body sway, so BWSTT help in maintaining balance of the body and help guide and improve the accuracy of voluntary movement of the head and trunk in space. Patients with BWS showed raised center of gravity, leading to limited downward excursion, decreased percentage of stance, decreased total double-limb support time, decreased hip and knee angular displacement, and increased single limb support time.¹⁶

Benedetti in 2009 reported that treadmill exercise can safely improve early anomalies of posture and gait in early MS patients. They found that Indices of both sway path and sway area used for postural stability measurement were reduced after BWS training exercises in their patients.¹⁷

The occurrence of stride length in patients with MS could be a result of different factors including weakness, spasticity, poor sensory feedback and risk of falls. Patients on BWS training showed better improvement in their stride length. BWS training clearly helps the patients to better control these hindering factors. This was more obvious when compared with full body weight training. McCain and colleagues 2008 reported that Application of locomotor treadmill training with partial BWS even before over ground gait training may be more effective in establishing symmetric and efficient gait. They found that gait analysis showed increased knee flexion during swing and absence of knee hyperextension in stance for the treadmill group. In addition, more normal ankle kinematics at initial contact and terminal stance were observed in the treadmill group. Improved gait symmetry in the treadmill group was confirmed by measures of single support time, hip flexion at initial contact, maximum knee flexion, and maximum knee extension during stance.¹⁸

Cadence was significantly increased due to training on the treadmill with the use of BWS than who did not receive partial BWS. Hesse and colleagues 1999 found that Treadmill training with partial body weight support in hemiparetic subjects

allows them to practice a favorable gait characterized by a greater stimulus for balance training because of the prolonged single stance period of the affected limb, a higher symmetry, less plantar flexor spasticity, and a more regular activation pattern of the shank muscles as compared with floor walking.¹⁹

Recently Schwartz and colleagues in 2011 reported that after training of MS patients with body weight-supported treadmill not only some gait parameters improved significantly following the treatment but both functional independency measures and EDSS scores improved significantly post-treatment. This was not the case in our population which could be explained by the small number of the patients. In addition, the relative low level of disability of the patients in this study and the difference in training time could explain this difference.²⁰

A point of strength in this study is the combination between both the conventional physiotherapy training and the treadmill training. This gives us to evaluate the beneficial effect of the BWSTM alone on the gait and disability in MS and also the impact of the BWSTM on improving the outcome of the conventional physiotherapy training. This was seen in the significant improvement in the functional balance of the gait measured by the timed get-up and go test. Finch and colleagues 1991 have proposed that removal of body weight may facilitate the expression of gait patterns. By providing BWS during treadmill walking, both balance and locomotion are simultaneously being retrained, rather than separately addressed as in conventional physical therapy practice.¹⁴

Possible explanations for the improvements are improved strength and aerobic fitness, which could improve one's sense of physical health and reduce fatigue by improving locomotor efficiency. In addition, endorphin release could reduce the burden of pain allowing better involvement in training and improving the locomotor abilities.

Conclusion

BWSTM increase self-confidence and self-efficacy with promises of new hope for control over an unpredictable disease. In addition, BWSTM training reduces the physical burden of the exercises.

[Disclosure: Authors report no conflict of interest]

REFERENCES

- Kaipust JP, Huisinga JM, Filippi M, Stergiou N. Gait Variability Measures Reveal Differences between Multiple Sclerosis Patients and Healthy Controls. *Motor Control*. 2012; 16(2):229-44.
- El-Ghoneimy A, Dief R, Soliman R, Oraby M. Gait characteristics in multiple sclerosis. *Egypt J Neurol Psychiat Neurosurg*. 2011; 48(3): 285-290.
- Kurtzke JF. Rating impairment in multiple sclerosis: an expanded disability status scale (EDSS). *Neurology* 1983; 33: 1444-52.
- Wilson M, Qureshy H, Protas E, Holmes A, Krouskop T, Sherwood A. Equipment specifications for supported treadmill ambulation training: A technical note. *J Rehabil Res Develop*. 2000; 37: 153-164.
- Murray M, Spurr G, Gardner G, Mollinger L. Treadmill vs. floor walking: Kinematics, electromyogram, and heart rate. *J Appl Physiol*. 1985; 59: 87-91.
- Polman CH, Reingold SC, Edan G, Filippi M, Hartung HP, Kappos L, et al. Diagnostic criteria for multiple sclerosis: 2005 revisions to the "McDonald Criteria". *Ann Neurol*. 2005; 58(6):840-6.
- Kappos L, Antel J, Comi G, Montalban X, O'Connor P, Polman CH, et al. FTY720 D2201 Study Group. Oral fingolimod (FTY720) for relapsing multiple sclerosis. *N Engl J Med*. 2006; 355(11): 1124-40.
- Correale J, Fiol M, Gilmore W. The risk of relapses in multiple sclerosis during systemic infections. *Neurology*. 2006; 67(4): 652-9.
- Tsushima H, Morris M, McGinley J. Test-retest reliability and inter-tester reliability of kinematic data from a three-dimensional gait analysis system. *J Jpn Phys Ther Assoc*. 2003; 6: 9-17
- Morris M, Ianssek R, McGinley J, Matyas T, Huxham F. Three-Dimensional gait biomechanics in Parkinson's disease: evidence for a centrally mediated amplitude regulation disorder. *Mov Disord*. 2005; 20: 40-50
- Chester LV, Biden EN, Tingley M. Gait Analysis. *Biomed Instrum Technol*. 2005; 39(1): 64-74
- Testerman C, Griend R. Evaluation of ankle instability using the Biodex Stability System. *Foot Ankle Int*. 1999; 20: 317-21.
- Baker P, Evans OM, Lee C. Treadmill gait retraining following fractured neck of femur. *Arch Phys Med Rehabil*. 1991; 72(9): 649-52.
- Finch L, Barbeau H, Arseneault B. Influence of body weight support on human gait: Development of a gait retraining strategy. *Phys Ther*. 1991; 71: 842-56.
- Wier LM, Hatcher MS, Triche EW, Lo AC. Effect of robot-assisted versus conventional body-weight-supported treadmill training on quality of life for people with multiple sclerosis. *J Rehabil Res Dev*. 2011; 48(4):483-92.
- Strathy F, Helm B, Simpson D. Ambulation training of neurological patients on the treadmill with a new walking assistance. *Phys Ther*. 1983; 79: 917-31.
- Benedetti MG, Gasparroni V, Stecchi S, Zilioli R, Straudi S, Piperno R. Treadmill exercise in early multiple sclerosis: a case series study. *Eur J Phys Rehabil Med*. 2009; 45(1):53-9

18. McCain KJ, Pollo FE, Baum BS, Coleman SC, Baker S, Smith PS. Locomotor treadmill training with partial body-weight support before overground gait in adults with acute stroke: a pilot study. Arch Phys Med Rehabil. 2008; 89(4): 684-91
19. Hesse S, Werner C, Matthias K, Stephen K, Berteau M. Non-velocity-related effects of a rigid double-stopped ankle-foot orthosis on gait and lower limb muscle activity of hemiparetic subjects with an equinovarus deformity. Stroke. 1999; 30(9): 1855-61
20. Schwartz I, Sajin A, Moreh E, Fisher I, Neeb M, Forest A, et al. Robot-assisted gait training in multiple sclerosis patients: a randomized trial. Mult Scler. 2012; 18(6): 881-90.

الملخص العربي

تحسين المشي والاتزان في مرضى التصلب المتناثر بواسطة التعليق الجزئي للجسم أثناء التدريب على جهاز المشي

يعانى مرضى التصلب المتناثر فى الجهاز العصبى من إصابات تؤثر على القدرة على المشى والحفاظ على الاتزان وقد أجريت هذه الدراسة لمعرفة تأثير التدريب على جهاز المشى المنتظم بواسطة التعليق الجزئى للجسم. شارك في هذه الدراسة ٢٤ مريضا من الجنسين. تم تقسيم المرضى الى مجموعتين المجموعة الأولى تلقت علاج طبيعى وتدريب بكامل وزن الجسم. أما المجموعة الثانية فقد عولجت بنسبة تعليق ٤٠% من وزن الجسم على جهاز المشى المنتظم لمدة ٦ أسابيع. تم تقييم جميع المرضى معمليا قبل وبعد العلاج عن طريق التحليل الأكلينيكي بواسطة قياس اختبار النهوض والسير الميقاتي ومعدل الاتزان الكلي وأيضا التحليل الكينيماتيكي بواسطة جهاز تحليل الحركة ثلاثى الأبعاد ويشمل (طول الخطوة، عدد الخطوات فى الدقيقة).

وأظهرت المعالجة والدلالات الإحصائية لنتائج القياسات المعملية البحثية إن هناك تحسن ذو دلالة إحصائية واضحة لجميع المرضى بعد العلاج وكانت أفضل النتائج لصالح المجموعة الثانية. لذا يمكن اعتبار التعليق الجزئى للجسم وسيلة فعالة ومفيدة جدا للمرضى تؤخذ فى الاعتبار عند وضع خطة وبرنامج العلاج الطبيعى لمرضى تصلب المتناثر.

Copyright of Egyptian Journal of Neurology, Psychiatry & Neurosurgery is the property of Egyptian Society of Neurology, Psychiatry & Neurosurgery and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.