Zawadka Magdalena, Kochman Maciej, Sobiech Magdalena, Jabłoński Mirosław. External load application in gait and posture reeducation after diffuse axonal injury of the corpus callosum. A case report. Journal of Education, Health and Sport. 2018;8(8):24-33. eISSN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1296724
http://ojs.ukw.edu.pl/index.php/johs/article/view/5597

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part B item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eISSN 2391-8306 7

Received: 01.06.2018. Revised: 08.06.2018. Accepted: 23.06.2018.

External load application in gait and posture reeducation after diffuse axonal injury of the corpus callosum. A case report

Magdalena Zawadka[1], Maciej Kochman[2], Magdalena Sobiech[2], Mirosław Jabłoński[2]

[11]PhD student, Faculty of Health Sciences, Medical University of Lublin, Poland
[2] Department of Rehabilitation and Orthopedics, Medical University of Lublin, Jaczewskiego 8 Street 20-090 Lublin, Poland

Corresponding author: Magdalena Zawadka, ORCID ID 0000-0001-6087-017X, e-mail:magdalenazawadka91@gmail.com

Abstract

Traumatic brain injury caused car accidents is the one of the most common causes of diffuse axonal injury typically located at the grey-white matter junction, in the corpus callosum. A 58-year-old female patient Caucasian race was admitted to the Orthopedic and Rehabilitation Unit with head injury, broken right ulnar bone, numerous broken ribs and broken right iliac crest. Neurological examination resulted in right-sided hemiparesis. There were also coordination and balance disorders while sitting and standing. The patient was unable to walk. After physiotherapy treatment included external load application (ankle weights and rucksack with weights) in gait and posture reeducation, patient has improved balance, locomotion and body posture. However, application of external loads during walk and posture reeducation needs to be further investigated with greater number of participants and control group.

Key words: posture, gait, corpus callosum, diffuse axonal injury

Introduction

Traumatic brain injury is the one of the most common causes of death and disability in adults living in industrialized countries. Closed head trauma arising from falls and motor vehicle crashes is a common cause of diffuse axonal injury typically located at the grey-white matter junction, in the corpus callosum [1]. The corpus callosum (CC) is the principal white matter fiber bundle connecting two hemispheres. There is a strong postulation that the motor CC is important for bimanual coordination and learning of bimanual motor skills [2] and callosal disconnection may cause a limb-kinetic and ideomotor apraxia [3], motor impersistence (an inability to sustain a certain position or movement due to isolated corpus callosal lesion) caused more often by right hemisphere than left hemisphere lesions [4], nondominant limb agraphia, apraxia, dominant limb constructional apraxia, and intermanual conflict [5].

As the CC primary function in mediating interhemispheric communication, callosal pathway disruptions can have a profound impact on cognitive functioning, including the speed of information processing [6]. Symptoms of CC injury may lead to functional independence, locomotion problems and rising risk of falling.

Case Description

A 58-year-old female patient Caucasian race was admitted to the Orthopedic and Rehabilitation Unit in our hospital in February 2018. In December 2017 the patient was admitted to the Intensive Care Unit because of injuries suffered as a result of a car accident. A cranial CT scan of the head revealed diffuse axonal injury of CC. The patient had also broken right ulnar bone, numerous broken ribs and broken right iliac crest.

Neurological examination resulted in right – sided hemiparesis, right – sided sensation disorders, right – sided positive Babinski sign and symptoms of facial nerve damage. There were also coordination and balance disorders while sitting and standing. Further examination revealed stated limited consciousness, hypertension, bowel and urinary incontinence, insomnia as well as anxiety and mood disorders. At this time the patient was able to perform sit-to-stand with high walker with assistance. The patient was unable to walk.

At the time of the initial medical examination in our department she had a height of 176cm, body weight of 62.0 kg.

The patient stayed on our ward for eleven weeks. Physiotherapy treatment program included:

- Upper and lower limb resistance exercises,
- Core stability exercises
- Coordination exercises
- Proprioceptive neuromuscular facilitation exercises for upper and lower limbs (PNF concept)
- Walking re – education with the use of high walker, 4 – wheeled walker, walking with the Nordic walking sticks, walking with the walker and with the 1 kg load placed in the lower limbs (2kg altogether), and walking with the walker and with the 2 kg load (placed in the rucksack in front of the chest) (Figure 1).

Hydrotherapy (whirlpool bath) for upper and lower limbs, low frequency magnetic field for pelvis area, TENS for right iliac crest and laser (scanner) for right iliac crest were included in the physiotherapy treatment program.

At the discharge the patient was able to walk independently with a walker or with assistance without aids. Timed Up&Go Test (TU&GT) was then performed. The results were:

- 53s for walking with a walker
- 52s for walking with the walker and with the 2 kg load in the chest
- 59s for walking with 1kg load in the both lower limbs (2 kg altogether) and 2kg load in the chest

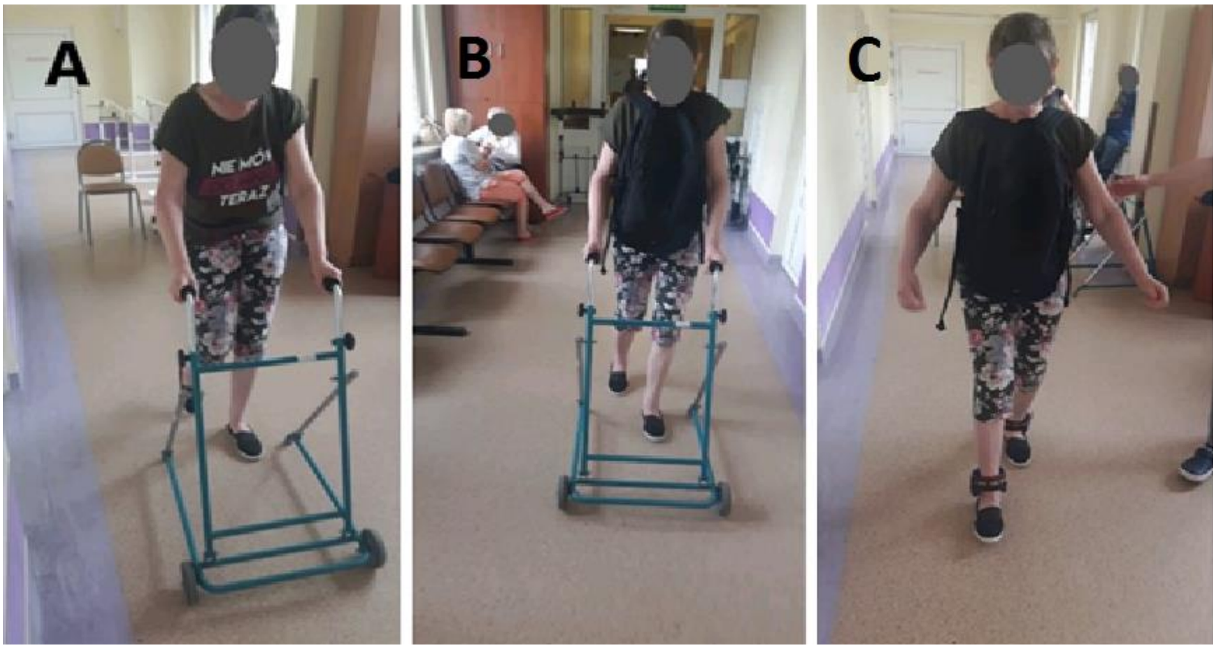

Figure 1. The patient while walking: A- with the walker without external load; B- with the walker and 2 kg load placed in the rucksack in front of the chest; C- with the 1 kg ankle weights (2kg altogether) and 2 kg load placed in the rucksack in front of the chest;

Management and Outcome

The Formetric 4D system by Diers Medical Systems has been used for body posture and foot pressure examination. This tool is a surface topography system, which projects stripes of white light on the back of standing patient and captures digital photos to assess pinpoint surface asymmetry and identify bony landmarks. System utilizes a complex algorithm to quickly create a three dimensional representation of the patient's spine without exposing them to harmful radiation. Video rasterstereography (Formetric-system) is already used successfully for quality management—especially in the analysis of result quality in the rehabilitation of patients with scoliosis and Scheuermann's disease [7,8].

At the day of discharge (April 2018) the patient was asked to participate in the body and foot posture evaluation. The written consent to participate in the study was given by the patient before the measurements were taken.

Measures were taken over a 6-second interval, taking 2 pictures per second. The 12 images acquired are evaluated and averaged by the machine's software (Figure 2). The evaluation of body posture and foot pressure included standing with additional load placed in the rucksack and without external load. There were three measurements taken (no load, rucksack in right hand and in left hand) for posture evaluation (Table 1). There is no possibility to evaluate posture using Diers Formetric 4D when rucksack is placed on the patient's chest or back.

Figure 2. One of 12 photos captured by Formetric 4D system (Diers Medical Systems) which presents patient position during evaluation and projected stripes of white light on the back of standing patient.

The pressure difference between the legs was measured using Pedoscan device, which is a device for measuring the pressure distribution under both feet during standing. This device contains pressure sensors and records the foot pressure to be displayed quickly and precisely (using DICAM program) as a pressure map with colors for each sensor or area on the computer screen.

The foot pressure recording allows the pressure distribution, pressure peaks, and body's center of gravity displacement to be captured while standing. This device measures the difference in pressure (difference of maximum pressure, difference of average pressure, difference of support area) between both lower limbs during standing.

In this study, 5 measurements were taken while subject stood on the plate of the device with both feet. Patient was asked to stand in her normal, comfortable posture. The examiner did not position the participant. Participant was asked to step away from the machine between measurements. No data sets were excluded. In the first trial the patient was examined with no additional load. Additional load (2 kg, placed in the rucksack) was added in the next trials. In the second trial the rucksack was held by patient in front of their chest, in the third trial the rucksack was held on patient’s back, in the fourth trial the rucksack was held in the right hand and in the fifth trial the rucksack was held in the left hand.

Because measurements were quite difficult and exhausting for patient there was no repetition of any measurement.

Table1. Back posture measurements.

Parameter	Without additional load	Rucksack in right hand	Rucksack in left hand
lateral deviation (symmetry line) _ VPDM _ (rms) _ [mm]	15.83	8.94	22.49
lateral deviation (symmetry line) _ VPDM_(max)_[mm]	23.05	17.67	34.59
lateral deviation (amplitude)_[mm]	32.14	28.39	38.21
Trunk inclination [deg]	1.42	4.05	2.12
Trunk inclination (mm)+ forward; - backward	11.42	32.64	15.76
trunk imbalance (mm)+ to the right side; - to the left side	36.5	-1.26	50.05
Pelvic tilt (mm) + left side higher than right side, - right side is higher than left side	30.00	15.49	20.07
Thoracic Kyphosis maximal angle	41.74	39.58	43.74
Lumbar Lordosis maximal angle	26.84	22.01	23.25
Trunk torsion	10.41	9.81	9.52

RMS - root mean square; VPDM- Line between points: vertebra prominens (C7) point and midpoint between lumbar dimples.

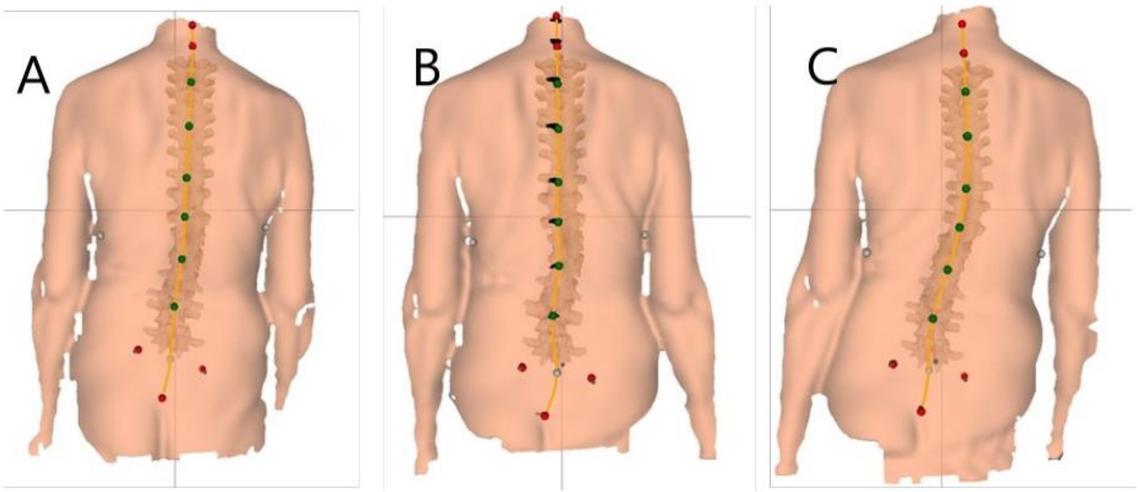

Figure 3. Changes of back posture: A-without additional load, B- rucksack in right hand, C-rucksack in left hand.

Holding additional load in right hand resulted in patient' back posture improvement. Lateral deviation and trunk imbalance decreased during holding rucksack in the right hand in comparison to the left- hand-loading. The trunk inclination increased and pelvic tilt decreased when patient held additional load in the right hand. In figure 3. patient posture has been showed.

Table 2. Foot pressure measurements

Parameter	No additional load			Rucksack in front of the chest			Rucksack on the back			Rucksack in the right hand			Rucksack in the left hand		
	L	R	T	L	R	T	L	R	T	L	R	T	L	R	T
Front loading (%)	17.64	11.47	29.11	22.22	13.01	35.23	21.38	17.98	39.36	17.74	13.75	31.49	19.41	13.17	32.58
Rear loading (%)	46.4	24.49	70.89	41.99	22.78	64.77	46.64	14	60.64	44.86	23.64	68.5	51.09	16.33	67.42
Total loading (%)	64.04	35.96	100	64.21	35.79	100	68.02	31.98	100	62.61	37.39	100	70.5	29.5	100
Maximum pressure (N/cm2)	38.13	18.23	56.36	40.53	15.82	56.35	31.84	10.23	42.07	36.15	15.18	51.33	38.63	9.37	48
Average pressure (N/cm2)	5.13	2.64	7.77	5.38	2.87	8.25	4.7	2.31	7.01	4.7	2.64	7.34	4.98	2.09	7.07
Support area (cm2)	120.56	131.41	251.97	122.8	128.42	251.22	154.25	147.89	302.14	141.52	150.51	292.03	150.13	149.76	299.89

L – left leg, R – right leg, T – total

In patient's normal position (no additional load) more pressure was put on the left heel. Standing with the rucksack in front of the chest resulted in changes of pressure distribution. More pressure were put on the front loading (both feet). Standing with the rucksack on the back resulted in increasing front loading and movement of the center of the gravity (more changes in the right foot pressure distribution). Holding additional load in the right hand did not result in significant changes in the feet distribution. Holding additional load in the left hand resulted in increasing left foot loading.

Holding additional loading in the back, in the right and left hand increased also support area.

In figure 4. the changes of the patient feet distribution have been showed.

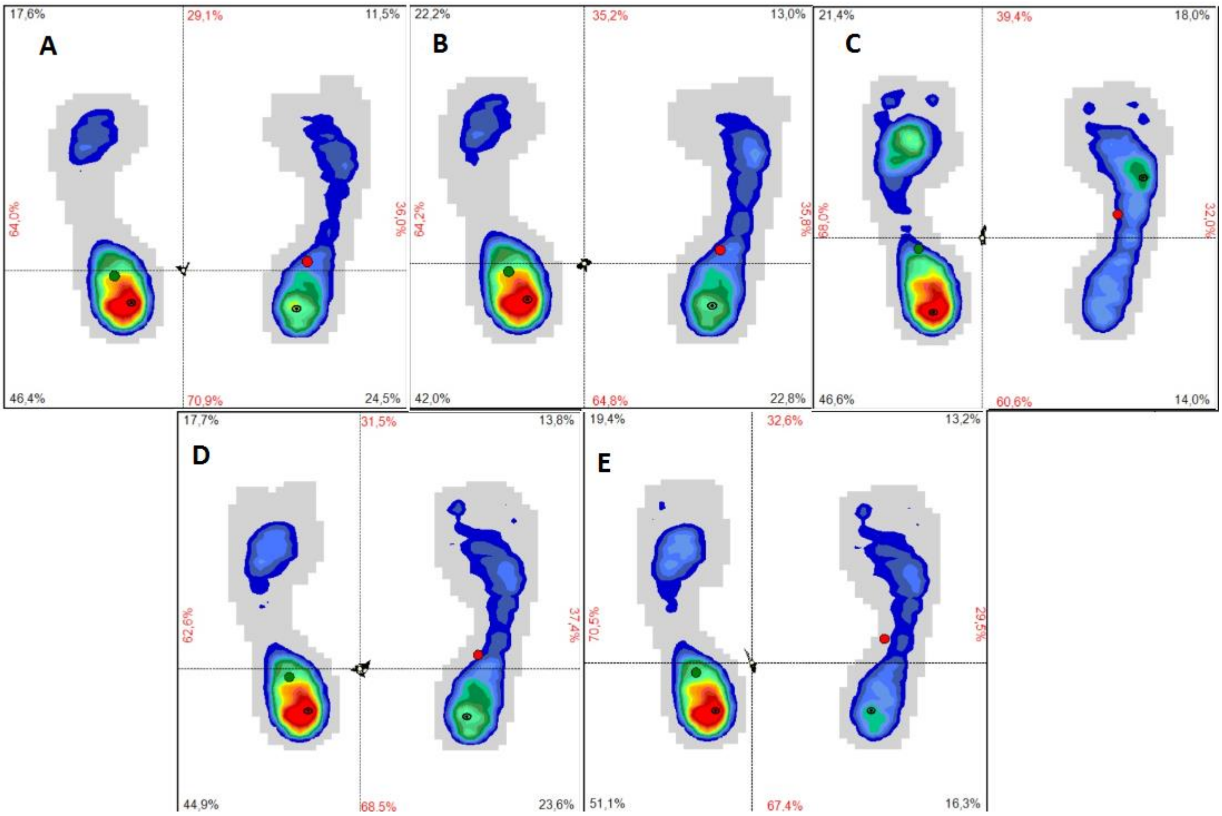

Figure 4. Changes of feet pressure distribution: A – no additional load, B – rucksack in front of the chest, C – rucksack on the back, D – rucksack in the right hand, E – rucksack in the left hand.

Discussion

Patients after traumatic brain injury may continue to have impairments in their postural control and motor control abilities [9]. They may demonstrate increased sway while standing and have difficulty processing sensory information. During the gait, the reductions in the whole-body center of mass displacement may be observed as a result of a slower walking speed and a shorter stride length. Basford et al. suggest that subjects with brain injury reduced their sagittal plane movement during gait to maintain their balance [10].

Rehabilitation after brain injury is important period of recovery. Many previous studies was looking for the best rehabilitation protocol after head trauma [11,12]. As Hugentobler et al. suggest, general postural control, balance and motor control exercises should be incorporated for all patients after traumatic brain injury [9]. Cheng et al. proved that symmetrical body-weight distribution training may improve sit-to-stand performance and, consequently, decrease the number of falls by stroke patients [13].

WHO guideline inform that falls are the second leading cause of accidental or unintentional injury deaths worldwide. Each year an estimated 646 000 individuals die from falls globally. Prevention strategies should emphasize education, training, creating safer environments, prioritizing fall-related research and establishing effective policies to reduce risk [14] WHO 2018).

Falls are usually caused by an interaction of a number of risk factors. The more risk factors there is, the greater risk of falling. Therefore falls prevention and investigating body balance is very important to reduce the risk. Poor balance affecting unsteadiness on the feet is one of the risk factors of the fall. It may be caused by patient health condition such as stroke, Parkinson's disease and other neurological conditions [15]. In this study external load was used to improve posture and balance during walking and to reduce risk of fall.

Previous studies confirm that there are significant three-dimensional changes in the back shape in response to asymmetrical loading [16,17]. Changes in the ground reaction forces when carrying loads have been found as well (18). Body posture regulation is modulated by the central nervous system, which, through the action of postural reflexes, adjusts posture, balance and body displacement [19]. Treadmill walking therapy with additional load was used previously to improve locomotion of subjects with Parkinson's disease [20–22]**.** It has been suggested that treadmill training of Parkinson's disease can be enhanced by the addition of load, which seems to promote improvement of the proprioception. There is evidence that the increase in body load during treadmill walking in healthy subjects improves reflex activity and leg extensor muscle activity [23]. Load information is used to modify the reflex response and to achieve the desired posture during walking [24].

Conclusion

Diers posture measuring device is helpful in assessment of desired trunk position during rehabilitation after cerebral injury. Programmed differences seen on the body posture and foot pressure distribution of the patient with CC diffuse axonal injury while holding additional loads could be beneficial, however this study needs to be further investigated.

References

1. Arenth PM, Russell KC, Scanlon JM, Kessler LJ, Ricker JH. Corpus callosum integrity and neuropsychological performance after traumatic brain injury: a diffusion tensor imaging study. J Head Trauma Rehabil. 2014 Apr;29(2):E1–10.

2. Wahl M, Lauterbach-Soon B, Hattingen E, Jung P, Singer O, Volz S, et al. Human motor corpus callosum: topography, somatotopy, and link between microstructure and function. J Neurosci Off J Soc Neurosci. 2007 Nov 7;27(45):12132–8.

3. Acosta LM, Bennett JA, Heilman KM. Callosal disconnection and limb-kinetic apraxia. Neurocase. 2014;20(6):599–605.

4. Kim HJ, Kim D, Won D-H, Chin J, Lee KH, Seo SW, et al. Callosal Motor Impersistence: A Novel Disconnection Syndrome. Cogn Behav Neurol Off J Soc Behav Cogn Neurol. 2017 Jun;30(2):68–72.

5. Taylor PN, Forsyth R. Heterogeneity of trans-callosal structural connectivity and effects on resting state subnetwork integrity may underlie both wanted and unwanted effects of therapeutic corpus callostomy. NeuroImage Clin. 2016 Jul 26;12:341–7.

6. Wu TC, Wilde EA, Bigler ED, Li X, Merkley TL, Yallampalli R, et al. Longitudinal Changes in the Corpus Callosum following Pediatric Traumatic Brain Injury. Dev Neurosci. 2011 Feb;32(5–6):361–73.

7. Frerich JM, Hertzler K, Knott P, Mardjetko S. Comparison of radiographic and surface topography measurements in adolescents with idiopathic scoliosis. Open Orthop J. 2012;6:261–5.

8. Weiss H-R, Dieckmann J, Gerner HJ. The practical use of surface topography: following up patients with Scheuermann's disease. Pediatr Rehabil. 2003 Mar;6(1):39–45.

9. Hugentobler JA, Vegh M, Janiszewski B, Quatman-Yates C. Physical therapy intervention strategies for patients with prolonged mild traumatic brain injury symptoms: A case series. Int J Sports Phys Ther. 2015 Oct;10(5):676–89.

10. Basford JR, Chou L-S, Kaufman KR, Brey RH, Walker A, Malec JF, et al. An assessment of gait and balance deficits after traumatic brain injury. Arch Phys Med Rehabil. 2003 Mar 1;84(3):343–9.

11. Malec JF, Basford JS. Postacute brain injury rehabilitation. Arch Phys Med Rehabil. 1996 Feb 1;77(2):198–207.

12. Wild KRH von. Neurorehabilitation Following Craniocerebral Trauma. Eur J Trauma. 2005 Aug 1;31(4):344–58.

13. Cheng P-T, Wu S-H, Liaw M-Y, Wong AMK, Tang F-T. Symmetrical body-weight distribution training in stroke patients and its effect on fall prevention. Arch Phys Med Rehabil. 2001 Dec 1;82(12):1650–4.

14. Falls [Internet]. [cited 2018 Jun 11]. Available from: http://www.who.int/news-room/fact-sheets/detail/falls

15. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. Maturitas. 2013 May;75(1):51–61.

16. Negrini S, Negrini A. Postural effects of symmetrical and asymmetrical loads on the spines of schoolchildren. Scoliosis. 2007 Dec 1;2:8.

17. O'Shea C, Bettany-Saltikov JA, Warren JG. Effect of same-sided and cross-body load carriage on 3D back shape in young adults. Stud Health Technol Inform. 2006;123:159–63.

18. Birrell SA, Hooper RH, Haslam RA. The effect of military load carriage on ground reaction forces. Gait Posture. 2007 Oct;26(4):611–4.

19. Massion J. Postural Control Systems in Developmental Perspective. Neurosci Biobehav Rev. 1998 Mar 4;22(4):465–72.

20. Filippin NT, da Costa PHL, Mattioli R. Effects of treadmill-walking training with additional body load on quality of life in subjects with Parkinson's disease. Rev Bras Fisioter Sao Carlos Sao Paulo Braz. 2010 Aug;14(4):344–50.

21. Toole T, Maitland CG, Warren E, Hubmann MF, Panton L. The effects of loading and unloading treadmill walking on balance, gait, fall risk, and daily function in Parkinsonism. NeuroRehabilitation. 2005 Jan 1;20(4):307–22.

22. Trigueiro LC de L, Gama GL, Ribeiro TS, Ferreira LGL de M, Galvão ÉRVP, Silva EMG de SE, et al. Influence of treadmill gait training with additional load on motor function, postural instability and history of falls for individuals with Parkinson's disease: A randomized clinical trial. J Bodyw Mov Ther. 2017 Jan;21(1):93–100.

23. Stephens MJ, Yang JF. Loading during the stance phase of walking in humans increases the extensor EMG amplitude but does not change the duration of the step cycle. Exp Brain Res. 1999 Feb;124(3):363–70.

24. Fouad K, Bastiaanse CM, Dietz V. Reflex adaptations during treadmill walking with increased body load. Exp Brain Res. 2001 Mar;137(2):133–40.