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Vojta therapy versus balance training program on dynamic sitting balance in chronic motor complete spinal cord injury: a single-blind crossed-over trial study

Chatwalai Sonthikul[1*], Patima Kesorn[2], Pitsinee Kaoian[2], Apinya Malineerat[2]

[1] Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand.
[2] Undergraduate Student of the Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand.

KEYWORDS
Vojta therapy;
Balance training program;
Dynamic sitting balance;
Gross motor function assessment;
Spinal cord injury.

ABSTRACT
The purpose of this blind-assessor randomized crossover trial was to evaluate the effect of Vojta therapy (VT) and a balance training program (BTP) on dynamic sitting balance in individuals with thoracic chronic motor complete spinal cord injury (SCI). Eleven individuals with SCI (T2-T12, American Spinal Injury Association (ASIA) class A-B) were randomly assigned to undergo either VT or BTP for 45 minutes. One week later, the interventions were alternated. The primary outcome measures were dynamic sitting balance assessed via the modified Functional Reach Test (mFRT) and the ability to don and doff a T-shirt (the T-shirt test). Gross motor function assessment (GMFA) was the secondary outcome. All assessments were performed immediately before and after the intervention. The Mann-Whitney U test was used to compare the change score between interventions, and the Wilcoxon signed rank test was used to analyze the data within an intervention. There was not significant difference at before between interventions. VT was superior to BTP in yielding a statistically significant difference in dynamic sitting balance and gross motor function (p-value < 0.05). However, both interventions proved effective in improving dynamic sitting balance and gross motor function (p-value < 0.05) in those suffering from motor complete chronic SCI. A 45-minute VT and BTP program was able to improve dynamic sitting balance and gross motor function relating to the functional ability and activities daily living of individuals with thoracic SCI with a long post-injury time.

***Corresponding author:** Chatwalai Sonthikul, MSc. Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University, 15 Karnjanavanich Road, Kho Hong, Hat Yai, Songkhla 90110, Thailand. E-mail: chatwalai.s@gmail.com
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Introduction

Thoracic spinal cord injury (SCI) results in impaired sensorimotor function of the trunk and legs below the injury level. Due to a decreased control of the trunk, many individuals with thoracic SCI have poor sitting balance and remain wheelchair-dependent even after rehabilitation[1]. Good sitting balance is a fundamental component for functional activities of daily living in both the home and the community, such as grooming, dressing, wheelchair propulsion, transfer to and from the wheelchair, and reaching objects[2]. Furthermore, a previous study found that 31 percent of their participants reported more than 500 fall events in wheelchair-dependent SCI patients[3]. Therefore, improving the sitting balance is essential for achieving independence activities daily living in individuals with thoracic spinal cord injury[4].

There are different intervention methods for improving dynamic sitting balance in individuals with SCI [2,5-7]. Task-specific training is commonly used[5-7], and it involves intensive and repetitious practice following the principle of motor relearning[8,9]. A systemic review in 2018 found a moderate level of evidence that task-specific training interventions can improve sitting balance in the chronic stages of the disease[4]. In addition, these treatments require six to twelve weeks to yield any improvement in dynamic sitting balance[4]. The balance training program (BTP) is one type of task-specific training. Furthermore, a new intervention, Vojta therapy (VT), has been shown to improve balance[10].

VT was first used by Prof. Dr. Vaclav Vojta in 1959 for the treatment of children with cerebral palsy. Later, it was successfully applied to treat movement disorders in adults[11]. The basic principle of VT is reflex locomotion[12,13]. The reflex locomotion pattern is the "building blocks" used for movement and postural control, which are emerged by position correction and stimulation of the appropriate zone[12-14]. The position consists of supine and side lying (reflex rolling) and prone lying (reflex creeping)[12,13]. There are ten different zones on a human body[13]. Isometric muscles, which take part in the locomotion of the whole body, are activated via exteroceptors and the enteroceptors[10,12]. Afferent stimulation goes to the central nervous system and a connection between the spinal cord and the brain is established by propriospinal neurons[12,13]. In addition, a previous study also found that VT activated the transversus abdominis muscle which is one of the core muscles for providing proximal stability to improve balance[10,15-17].

To our knowledge, no study has used VT as an intervention in SCI patients. Hence, the aim of this study was to investigate the effects of VT and BTP on improving dynamic sitting balance in people suffering from chronic thoracic motor complete SCI.

Materials and methods

Trial design

An assessor-blind, randomized, 2x2 crossover trial study (switching from one intervention to another during study)[18] was undertaken at the Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University from December 2019 to February 2020. A computer-generated random intervention was obtained before beginning the trial by a person not involved in the recruitment of the participants. The participants, who passed the screening process and completed the initial assessment, were informed which intervention they received first. Using a repeated-measures crossover design, participants were randomized to receive 45 minutes of either VT or BTP, followed by a 1-week wash-out[18], after which the participants received the other intervention paradigm (Figure 1). This study used the crossover deign as a way to minimize the occurrence of participant heterogeneousness (e.g., age, gender, body mass index, etiology of disease, neurological level of injury which could have affected the results of the study).

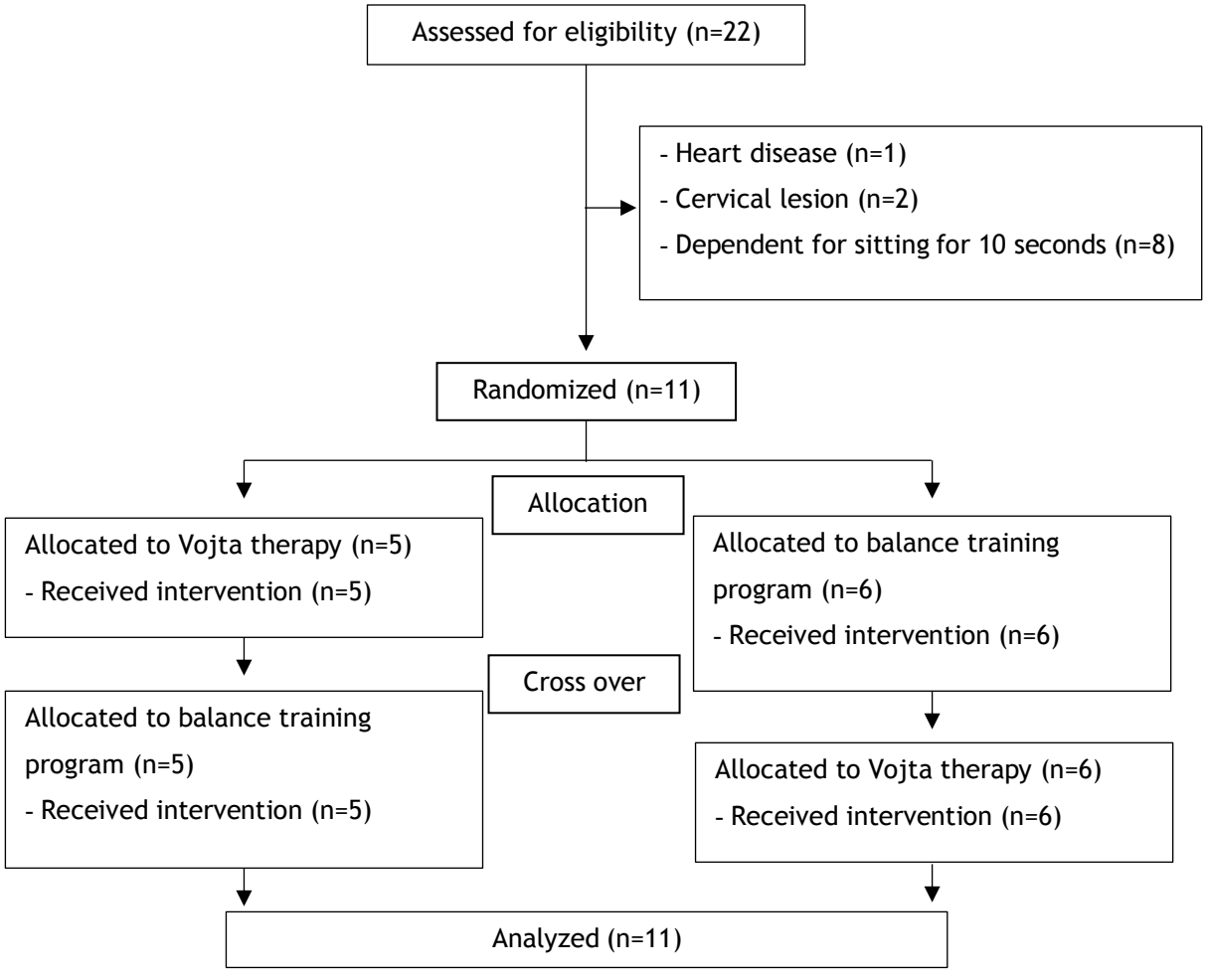


Figure 1 CONSORT (Consolidated Standards of Reporting Trial) flow diagram of randomized crossover design.

Participants

Participants were included if they had a motor complete SCI (classified as ASIA Impairment Scale (AIS) A to B) at a neurological level of injury between T2 and T12 for a duration of more than 12 months[19]. The additional inclusion criteria were the following: age between 18 and 60 years and the ability to sit unsupported for more than 10 seconds with a shoulder flexion of more than 90 degrees. Potential participants were excluded according to the following: had experienced VT within one month, had other neurological (e.g., stroke, traumatic brain injury, or Parkinson's disease, and had musculoskeletal (e.g., osteogenesis imperfecta) or cardiovascular problems (heart disease) that are precautions and contraindications for VT. The study protocol was approved by the Human Research Ethics Committee (HREC), Faculty of Medicine, Prince of Songkla University (No. 62-292-30-2). All the participants understood and acknowledged the details of the study and the risk involved and provided a written informed consent before the study's commencement.

Sample size calculation

The sample size was calculated based on a pilot study among five participants using the formula described below

$$n = \left[\frac{(Z_{\alpha/2} + Z_{\beta})\sigma}{\Delta} \right]^2$$

The sample size was estimated on the basis of the dynamic sitting balance measured on a modified functional reach test (mFRT) after intervention and assuming an 80.0% power, 5.0% significance, and 20.0% dropout rate. In order to detect a statistical significance between interventions on mFRT, a minimum total sample size of 11 was required for the study.

Interventions

Participants received two programs for 45 minutes. The programs consisted of 15 minutes of prolonged passive stretching before the intervention and 30 minutes of VT or BTP depending on the treatment order. The prolonged passive stretching consisted of five poses: trunk rotator muscles, hip flexor muscles, hip adductor muscles, ankle plantar flexor muscles, and hip extensor muscles. The participants were stretched holding each pose for 15 seconds and repeating it five times.

VT was administered by a Vojta therapist, who is licensed and has an experience of more than two years. The participants received 30 minutes of VT in the supine position (reflex rolling) for the chest zone, the side lying position (reflex rolling) for the scapular and anterior superior iliac spine (ASIS) zone, and the prone position (reflex creeping) for the calcaneus zone[20]. Each position was stimulated for 10 minutes on both left and right sides (Figure 2).

A. Chest zone in reflex rolling

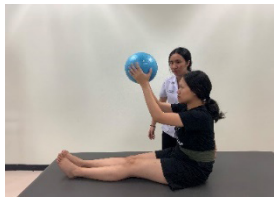
B. Scapular and ASIS zone in reflex rolling

C. Calcaneus zone in reflex creeping

Figure 2 Vojta therapy

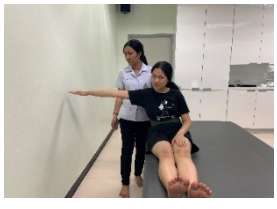
The BTP is modified from previous study[6]. It comprised 24 different exercises in three sitting positions, which consisted of long sitting on the bed, side sitting, and side sitting on the balance board. Each position involved eight poses composed of static sitting balance training for one minute, ball elevation 10 times, front reaching 10 times, right and left side reaching 10 times, cross right and left side reaching 10 times, and front reaching to contact the feet 10 times (Figure 3).

A. Static sitting balance on the bed



B. Ball elevation sitting on the bed

C. Front reaching sitting on the bed



D. Right side reaching sitting on the bed

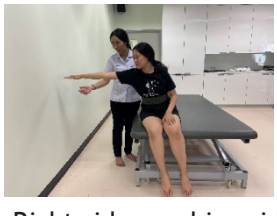
E. Crossed right side reaching sitting on the bed

F. Front reaching to contact the feet sitting on the bed

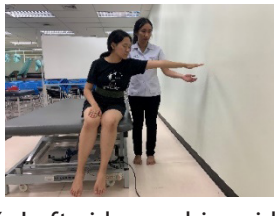
G. Static side sitting balance

H. Ball elevation side sitting

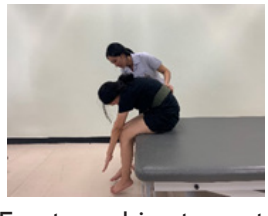
I. Front reaching side sitting



J. Right side reaching side sitting



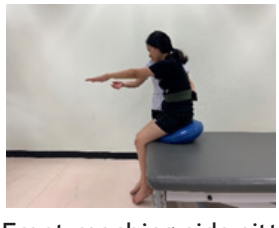
K. Left side reaching side sitting



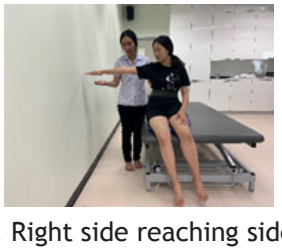
L. Front reaching to contact the feet side sitting

M. Static balance side sitting on the balance board

N. Ball elevation side sitting on the balance board



O. Front reaching side sitting on the balance board



P. Right side reaching side sitting on the balance board

Q. Left side reaching side sitting on the balance board

R. Front reaching to contact the feet side sitting on the balance board

Figure 3 Examples of exercises in the balance training program

Outcome

All assessments were made both before and after the intervention by one assessor blinded to the participants' treatment allocation. Participants were asked not to discuss their intervention allocation with the assessor.

Primary outcome

Dynamic balance was the primary outcome of this study, which was measured using two assessments-mFRT and T-shirt test. mFRT measures spatial variables, while the T-shirt test measures temporal variables. mFRT has been modified to evaluate dynamic balance in a sitting position in individuals with SCI[21]. This test has excellent reliability and is not complicated for assessment[21]. Participants sat at the edge of the bed with hips and knees flexed at 90° and feet resting on the floor[21]. The distance between the popliteal fossa and the edge of the bed was about two inches[21]. The tape measure was placed along the subject shoulder at the level of the acromion[21]. The tip of the middle finger served as the landmark for measuring the distance in centimeters. For forward mFRT, the participants flexed the dominant shoulder at 90° reaching forward as far as possible without turning the trunk or using the hand for support[19]. During right mFRT, the participants abducted the right shoulder 90° reaching forward as far as possible without turning the trunk or using the hand for support[22]. When performing the left mFRT, the participants abducted the left shoulder 90° reaching forward as far as possible without turning trunk or using the hand for support[22]. Each participant had two practice trials followed by three trials tested with a 15-second rest between trials. The average of the results from three trials was used for data analysis.

In addition, the T-shirt test was used to assess dynamic balance in the sitting position as a functional task, which measured the time required to put on and take off the shirt[23]. This test has excellent reliability, takes less than three minutes, and requires a minimal amount of equipment[23]. Participants sat at the edge of the bed with the feet resting on the floor. A T-shirt one size larger than the participants' normal size was placed face down on a table in front of the participants that was at the height of their iliac crests[23]. The participants were asked to put on and take off the T-shirt as quickly as possible. The test was repeated twice, and the average times calculated from each component (on, off, and total time) was used in data analysis.

Secondary outcome

This study used gross motor function assessment because it is one of the components of functional ability. It evaluates the amount of time to move from supine position to another position; from the supine position to right side lying, from the supine position to left side lying, and from the supine position to sitting. The test was repeated for three times, and the average times were used in data analysis.

Statistical analysis

SPSS 23.0 was used for the statistical analysis of this study. Due to the small number of participants, this study used non-parametric statistics to analyze the data. The Mann-whittney U test was employed to compare the change in scores between VT and BTP. A Wilcoxon signed rank test was also performed to investigate whether there was any within-group difference. The level of statistical significance was set at $\alpha = 0.05$.

Results

Table 1 presents demographics and baseline characteristics of 11 participants (eight male and three females). The median of age, weight, height, and BMI were 49.00 years (interquartile range (IQR) 35.00 to 53.00), 65.00 kg (IQR 62.80 to 70.00), 165.00 cm (IQR 165 to 168), and 23.59 kg/m^2 (IQR 20.76 to 25.71), respectively. All participants had etiology from trauma. Four participants had the 12th thoracic level, three participants had the 11th thoracic level, and another one had the 2nd, 4th, 5th, and 6th thoracic level. The median of months post injury was 214.00 months (IQR 164 to 240). Six participants had AIS class A, while five participants had AIS class B.

Table 1 Demographics and baseline characteristics (n=11)

Participants	Age (year)	Gender	Weight (kg)	Height (cm)	BMI (kg/m²)	Etiology	Level of lesion	Months post injury	ASIA Impairment Scale	Presence of the spasticity	Treatment 1	Treatment 2
1	35	Male	65	167	23.31	Trauma	Thoracic 5	157	A	No	Balance	Vojta
2	59	Male	65	165	23.88	Trauma	Thoracic 11	240	A	No	Vojta	Balance
3	33	Male	70	162	26.67	Trauma	Thoracic 4	187	A	Yes	Vojta	Balance
4	47	Male	65	166	23.59	Trauma	Thoracic 11	214	A	No	Vojta	Balance
5	51	Female	65	165	23.88	Trauma	Thoracic 6	154	A	No	Balance	Vojta
6	48	Male	64	178	20.20	Trauma	Thoracic 2	354	A	Yes	Balance	Vojta
7	52	Female	48	160	18.75	Trauma	Thoracic 12	164	B	Yes	Vojta	Balance
8	34	Male	62.8	168	22.25	Trauma	Thoracic 12	218	B	No	Vojta	Balance
9	49	Female	83	165	30.49	Trauma	Thoracic 11	221	B	No	Balance	Vojta
10	53	Male	60	170	20.76	Trauma	Thoracic 12	172	B	No	Balance	Vojta
11	58	Male	70	165	25.71	Trauma	Thoracic 12	380	B	No	Balance	Vojta
Median	49.00		65.00	165.00	23.59			214.00				
Q1, Q3	35.00, 53.00		62.80, 70.00	165.00, 168.00	20.76, 25.71			164.00, 240.00				

Table 2 Comparisons of variables between pre- and post-intervention in the Vojta therapy (VT) and balance training program (BTP)

Variables	Vojta therapy			Balance training program			Change		
	Before	After	*p*-value	Before	After	*p*-value	Vojta therapy	Balance training program	*p*-value
Modified FRT (cm)									
Forward	26.00 (23.47, 36.07)	31.67 (24.80, 37.57)	0.016*	28.57 (23.70 ,35.90)	29.90 (23.07, 32.73)	0.790	1.77 (0.10, 4.13)	0.13 (-4.37, 2.37)	0.049*
Right	8.37 (6.77, 10.93)	11.07 (9.10, 12.07)	0.003**	8.80 (6.40, 11.23)	9.67 (7.83, 11.73)	0.010*	1.67 (0.87, 2.23)	0.80 (0.17, 2.87)	0.123
Left	7.73 (6.87, 10.63)	9.63 (8.00, 11.10)	0.062	7.93 (6.37, 10.07)	8.13 (7.10, 10.37)	0.563	0.77 (0.30, 2.13)	0.17 (-0.63, 0.90)	0.052
T - shirt test (s)									
On	8.07 (6.32, 9.16)	6.95 (5.75, 8.33)	0.003**	8.11 (6.70, 9.95)	7.89 (5.86, 8.60)	0.004**	-0.69 (-1.80, -0.11)	-0.47 (-1.48, -0.33)	0.693
Off	4.97 (4.26, 6.05)	4.25 (4.13, 5.22)	0.016*	5.00 (4.03, 6.33)	4.71 (3.91, 6.27)	0.328	-0.53 (-0.80, -0.01)	-0.24 (-1.00, 0.25)	0.309
Total	12.46 (11.28, 14.11)	11.58 (10.29, 13.55)	0.003**	13.77 (10.56, 16.13)	12.59 (10.35, 14.80)	0.003**	-1.34 (-2.33, -0.76)	-0.60 (-2.47, -0.26)	0.375
Gross motor function (s)									
Supine to right side lying	1.92 (1.68, 2.40)	1.74 (1.60, 2.14)	0.722	1.77 (1.62, 2.24)	1.60 (1.47, 1.96)	0.041*	-0.02 (-0.27, 0.09)	-0.18 (-0.28, 0.01)	0.200
Supine to left side lying	1.77 (1.68, 1.96)	1.64 (1.51, 1.93)	0.013*	1.63 (1.42, 2.15)	1.74 (1.46, 1.96)	0.328	-0.24 (-0.42, -0.03)	-0.11 (-0.19, 0.08)	0.041*
Supine to sitting	2.99 (2.51, 3.57)	2.90 (2.65, 3.56)	0.248	2.99 (2.69, 3.27)	2.76 (2.37, 3.36)	0.109	-0.05 (-0.31, 0.07)	-0.24 (-0.43, 0.09)	0.869

Note: Median (Q1, Q3), [a]test by the Wilcoxon signed rank test, [b]test by the Mann-whittney U test, * *p*-value<0.05, *** *p*-value<0.01

Discussion

This study aimed to evaluate the efficacy of VT as compared with BTP in chronic motor complete SCI. The primary findings of this study demonstrated that VT elicited greater gains in dynamic sitting balance and gross motor function than BTP in motor complete SCI. This study is inconsistent with the findings of the study by Ha and Sung[20], which compared VT and traditional physical therapy after 6 weeks in 10 children with spastic cerebral palsy (CP). That study found no significant improvement in gross motor function using gross motor function measure (GMFM)-88. Nevertheless, they found significant difference in diaphragm movement between the study groups. However, this study is consistent with the finding of Epple et al. in 2020[24], which found that Vojta therapy was statistically superior to traditional physical therapy in postural control of individuals with severe acute stroke. The researcher hypotheses corresponding to the changes observed in this study were caused by VT activating the diaphragm, transversus abdominis muscle, and deep muscles of the spine[10,11,20]. The transversus abdominis is activated first among the trunk muscles before the extremities move to control trunk stability and the movement of the spine[25]. Furthermore, the transversus abdominis and diaphragm muscles work together to increase pressure in the abdomen, which provokes the physiological extension of the axial axis by rotating and extending each of its segments; this mechanism may help improve balance and gross motor function in VT more than BTP[10,11,20,25].

VT significantly immediately improved dynamic sitting balance and gross motor function in motor complete SCI. This result is consistent with Tayati et al[26], who found VT can immediately improve in dynamic balance in individuals with chronic stroke. In addition, this result is consistent with a previous study which found a significant improvement in sitting ability after VT in the children with CP[20]. Furthermore, the study of Lim and Kim (2013) also found a significant improvement in spatiotemporal gait parameters in the children with CP after VT when measured using the Vicon motion analysis[27]. This improvement can be attributed the ability of VT to stimulate reflex locomotion, which enables the proper sequential activation of motor centers controlling the muscles of both upper and lower extremities via propriospinal neurons[12]. Propriospinal neurons communicate information over short and long distances within the spinal cord to play a crucial role in motor control and sensory processing[28,29]. They act to coordinate between upper extremities, lower extremities, and the trunk based on the Sherrington's concept[12,28]. Furthermore, it has been reported that the activation of propriospinal circuits can promote the recovery of locomotion in individuals with SCI[28]. Furthermore, VT promotes the establishment of the pontomedullary reticular system and the function of the putamen[30]. This portion of the brain coordinates with the brain stem to govern posture control and locomotion before initiate movement[31]. Furthermore, VT also activates the transversus abdominis and diaphragm muscles and increases spinal elongation, which help improve both sitting balance and mobility[10,20,27,32].

The BTP improved significantly the dynamic balance and gross motor function in complete SCI. This result is supported by an earlier study, which found a significant immediately improvement in the dynamic balance of 20 individuals with SCI measured using the timed up and go test (TUG) after obstacle crossing training and conventional overground walking training[18].In addition, the study of Saensook et al. found an immediate significant improvement in dynamic balance after sit-to-stand training evaluated via the TUG in 27 individuals with SCI[33]. Moreover, a previous study in 2019 found a significant improvement in the ability to transition from supine position to right side lying after activity-based therapy assessed using the Modified Rivermead Mobility Index in 91 individuals with SCI[34]. This is consistent with the findings of a previous study, which suggested that task-specific balance training may augment plastic neuromuscular changes[35]. It has been reported that it can influence locomotor performance in individuals with SCI[35]. Furthermore, the core or trunk muscles used in the balance

training program can contribute to increased functional abilities[36].

In light of the fact that no side effects were observed in this study, it can be concluded that both VT and BTP are safe for individuals with SCI. However, a limitation of this study is the fact that the assessment was conducted immediately after the intervention, so any short-term or long-term effects of VT or BTP on dynamic sitting balance could not be determined. Future studies should employ a suitable follow-up as well as measure other parameters such as electromyography, muscle tone, muscle power, etc.

Conclusion

In conclusion, both VT and BTP were effective in the treatment of dynamic sitting balance and gross motor function in chronic motor complete SCI. However, the researchers observed a greater overall improvement in the scales of dynamic balance and gross motor function when the individuals were treated via VT.

Clinical implication

- VT achieves a significantly greater improvement in dynamic sitting balance and gross motor function in motor complete SCI
- Both VT and the BTP results in an immediate improvement of dynamic sitting balance and gross motor function in motor complete SCI.

Conflicts of interest

The authors declare no conflict of interest.

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References

1. Post MWM, van Asbeck FWA, van Dijk AJ, Schrijvers AJP. Services for spinal cord injured: availability and satisfaction. Spinal Cord 1997; 35(2): 109-15.
2. Tsang WWN, Gao KL, Chan KM, Purves S, Macfarlane DJ, Fong SSM. Sitting Tai Chi improves the balance control and muscle strength of community-dwelling persons with spinal cord injuries: a pilot study. Evid Based Complement Alternat Med 2015; 2015: 523852.
3. Nelson AL, Groer S, Palacios P, Mitchell D, Sabharwal S, Kirby RL, et al. Wheelchair-related falls in veterans with spinal cord injury residing in the community: a prospective cohort study. Arch Phys Med Rehabil 2010; 91(8): 1166-73.
4. Tse CM, Chisholm AE, Lam T, Eng JJ. A systematic review of the effectiveness of task-specific rehabilitation interventions for improving independent sitting and standing function in spinal cord injury. J Spinal Cord Med 2018; 41(3): 254-66.
5. Betker AL, Desai A, Nett C, Kapadia N, Szturm T. Game-based exercises for dynamic short-sitting balance rehabilitation of people with chronic spinal cord and traumatic brain injuries. Phys Ther 2007; 87(10): 1389-98.
6. Kim J-H, Chung Y, Shin H-K. Effects of balance training on patients with spinal cord injury. J Phys Ther Sci 2010; 22: 311-6.
7. Seong Choe H, Min D-K, Ahn J. Effects of anterior weight-shifting methods on sitting balance in wheelchair-dependent patients with spinal cord injury. J Phys Ther Sci 2018; 30(3): 393-7.
8. Harvey L, Ristev D, Hossain M, Hossain M, Bowden J, Boswell-Ruys C, et al. Training unsupported sitting does not improve ability to sit in people with recently acquired paraplegia: a randomised trial. J Physiother 2011; 57: 83-90.

9. Boswell-Ruys CL, Harvey LA, Barker JJ, Ben M, Middleton JW, Lord SR. Training unsupported sitting in people with chronic spinal cord injuries: a randomized controlled trial. Spinal Cord 2010; 48(2): 138-43.
10. Ha S-Y, Sung Y-H. Effects of Vojta method on trunk stability in healthy individuals. J Exerc Rehabil 2016; 12(6): 542-7.
11. Juárez-Albuixech ML, Redondo-González O, Tello I, Collado-Vázquez S, Jiménez-Antona C. Vojta Therapy versus transcutaneous electrical nerve stimulation for lumbosciatica syndrome: a quasi-experimental pilot study. J Bodyw Mov Ther 2020; 24(1): 39-46.
12. Gajewska E, Huber J, Kulczyk A, Lipiec J, Sobieska M. An attempt to explain the Vojta therapy mechanism of action using the surface polyelectromyography in healthy subjects: a pilot study. J Bodyw Mov Ther 2018; 22(2): 287-92.
13. Khan MH, Helsper J, Yang C, Grzegorzek M. An automatic vision-based monitoring system for accurate Vojta-therapy. In: 2016 IEEE/ACIS 15th International Conference on Computer and Information Science (ICIS). 2016. p. 1-6.
14. Steffen B, Christian G, Rainer B, Nina N, Wolfram M, Katrin S. Wearable pressure sensing for Vojta therapy guidance. Curr Dir Biomed Eng 2020; 6(3): 87-90.
15. Ferraro R, Garman S, Taylor R, Parrott JS, Kadlowec J. The effectiveness of transverse abdominis training on balance, postural sway and core muscle recruitment patterns: a pilot study comparison across age groups. J Phys Ther Sci 2019; 31(9): 729-37.
16. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med 2006; 36(3): 189-98.
17. Granacher U, Muehlbaue T, Zahner L, Gollhofer A, Kressig RW. Comparison of traditional and recent approaches in the promotion of balance and strength in older adults. Sports Med 2011; 41(5): 377-400.
18. Pramodhyakul W, Wattanapan P, Siritaratiwat W, Eungpinichpong W, Amatachaya S. Immediate effects of obstacle crossing training in independent ambulatory patients with spinal cord injury. Spinal Cord 2013; 51(5): 379-83.
19. Gao KL, Chan KM, Purves S, Tsang WWN. Reliability of dynamic sitting balance tests and their correlations with functional mobility for wheelchair users with chronic spinal cord injury. J Orthop Transl 2015; 3(1): 44-9.
20. Ha S-Y, Sung Y-H. Effects of Vojta approach on diaphragm movement in children with spastic cerebral palsy. J Exerc Rehabil 2018; 14(6): 1005-9.
21. O'Brien S, Leahy P, Barker S. Reliability of measurements obtained with a modified functional reach test in subjects with spinal cord injury. Phys Ther 1998; 78: 128-33.
22. Field-Fote EC, Ray SS. Seated reach distance and trunk excursion accurately reflect dynamic postural control in individuals with motor-incomplete spinal cord injury. Spinal Cord 2010; 48(10): 745-9.
23. Boswell-Ruys CL, Sturnieks DL, Harvey LA, Sherrington C, Middleton JW, Lord SR. Validity and reliability of assessment tools for measuring unsupported sitting in people with a spinal cord injury. Arch Phys Med Rehabil 2009; 90(9): 1571-7.
24. Epple C, Maurer-Burkhard B, Lichti M-C, Steiner T. Vojta therapy improves postural control in very early stroke rehabilitation: a randomised controlled pilot trial. Neurol Res Pract 2020; 2(1): 23.
25. Hodges PW, Richardson CA. Feedforward contraction of transversus abdominis is not influenced by the direction of arm movement. Exp Brain Res 1997; 114(2): 362-70.
26. Tayati W, Chompunuch N, Wongphaet P. Effect of Vojta therapy on balance and walking of community dwelling chronic stroke patients. ASEAN J Rehabil Med 2020; 30(1): 21-5.
27. Lim H, Kim T. Effects of vojta therapy on gait of children with spastic diplegia. J Phys Ther Sci 2013; 25(12): 1605-8.
28. Laliberte AM, Goltash S, Lalonde NR, Bui TV. Propriospinal neurons: essential elements of locomotor control in the intact and possibly the injured spinal cord. Front Cell Neurosci 2019; 13(512): 1-16.

29. Jankowska E, Lundberg A, Roberts WJ, Stuart D. A long propriospinal system with direct effect on motoneurones and on interneurones in the cat lumbosacral cord. Exp Brain Res 1974; 21(2): 169-94.
30. Hok P, Opavský J, Kutín M, Tüdös Z, Kaňovský P, Hluštík P. Modulation of the sensorimotor system by sustained manual pressure stimulation. Neuroscience 2017; 348: 11-22.
31. Sakai ST, Davidson AG, Buford JA. Reticulospinal neurons in the pontomedullary reticular formation of the monkey (Macaca fascicularis). Neuroscience 2009; 163(4): 1158-70.
32. Khiewcham P, Vongpipatana S, Wongphaet P, Thipsook K. Effect of Vojta therapy on gait of children with cerebral palsy. JThai Rehabil Med 2016; 26(3): 91-7.
33. Saensook W, Mato L, Chuadthong J, Promkeaw D, Manimmanakorn N, Sooknuan T, et al. Sit-to-stand training immediately improved functional ability of ambulatory patients with spinal cord injury. Arch AHS 2017: 29(3): 360-7.
34. de Oliveira CQ, Middleton JW, Refshauge K, Davis GM. Activity-Based Therapy in a community setting for independence, mobility, and sitting balance for people with spinal cord injuries. J Cent Nerv Syst Dis 2019; 11: 1-9.
35. Wolpaw JR, Tennissen AM. Activity-dependent spinal cord plasticity in health and disease. Annu Rev Neurosci 2001; 24(1): 807-43.
36. Seelen HAM, Potten YJM, Drukker J, Reulen JPH, Pons C. Development of new muscle synergies in postural control in spinal cord injured subjects. J Electromyogr Kinesiol 1998; 8(1): 23-34.