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Original Article

Influence of therapist supervision and bodyweight support on gait training in stroke patients

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ABSTRACT

Objectives: This study aims to investigate the effects of bodyweight support and therapist supervision on gait parameters and vital signs during overground gait training in stroke patients.

Patients and methods: Between August 2023 and September 2023, a total of 18 stroke patients (10 males, 8 females; mean age: 61.2±12.0 years; range, 32 to 81 years) with hemiparesis were included in this factorial-design study. The patients underwent three different walking conditions: supervised bodyweight support (SBS), unsupervised bodyweight support (UBS), and supervised training without bodyweight support (SWBS). Gait parameters, including velocity, cadence, gait distance, gait cycle, stride length, step length, and single limb support, as well as vital signs (pulse rate and SpO_2), were measured and compared using the 4-m walking test (4MWT) and 2-min walking test (2MWT).

Results: Twelve patients had an ischemic stroke, while six had a hemorrhagic stroke. The mean onset period was 9.61±5.96 months. Eight patients had right-sided paralysis, and 10 patients had left-sided paralysis. There were no significant differences in gait parameters or vital signs during the 4MWT and 2MWT among the SBS, UBS, and SWBS groups ($p>0.05$ for all).

Conclusion: Gait training using therapist supervised walking and bodyweight support may both be beneficial for stroke patients. However, incorporating both conditions into an intervention may not be efficient in terms of cost, space, and personnel utilization.

Keywords: Gait, hemiplegia, paresis, rehabilitation, stroke, weight-bearing.

Stroke is a highly prevalent disease worldwide and is a major cause of severe disability.[1] The primary goal of stroke rehabilitation by physical therapists is to restore function and minimize disabilities in patients. Improving gait function and balance in stroke patients is also a common goal for promoting independence and participation in social activities.[2] Furthermore, impairment in gait and balance significantly impacts the overall quality of life[3,4] of stroke patients, as well as their family members or primary caregivers.[5]

Numerous studies have been conducted on rehabilitation approaches to improve gait function and balance in stroke patients.[6-10] One approach, known as bodyweight-supported treadmill training (BWSTT) using harness support, as proposed by Sullivan et al.,[11] is known to facilitate coordination and motor control by supporting body weight and improving gait distance and balance ability.[12] However, it remains unclear whether BWSTT increases walking speed more than robotic walking or other forms of physical therapy. Additionally, BWSTT differs from overground gait training, as it is performed on a treadmill and requires speed adjustment based on the environment.

Several studies have explored the differences between BWSTT and overground gait training in patients with stroke.[13,14] Similarly, the effects of gait training using bodyweight-supported overground training (BWSOT) on stroke patients have recently been investigated.[15-18] This training allows physical therapists to observe and modify gait without

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physical strain.[16] Comparing the effects of gait training using BWSTT and BWSOT, it was found that BWSOT led to more noticeable improvements in gait parameters.[17] Additionally, BWSOT can help stroke patients achieve independent walking and enhance gait autonomy.[18]

While conducting BWSOT training to increase autonomy in stroke patients, it is important to investigate how gait parameters are impacted when patients walk at an appropriate speed and stride, both independently and with a therapist. However, there is a lack of studies examining the effects of therapist presence during BWSOT training on gait parameters, such as walking speed, distance, and gait cycle, in stroke patients. Therefore, in the present study, we aimed to investigate how the use of bodyweight support and the presence of a therapist during overground gait training impact various gait parameters in these patients and to provide evidence that would help therapists choose more effective gait training methods for stroke patients to achieve independent walking.

PATIENTS AND METHODS

This single-center, factorial-design study was conducted at Keunsol Medical Hospital in South Korea, Department of Rehabilitation Medicine between August 2023 and September 2023. Subjects were recruited through a recruitment announcement posted on each floor of the hospital from August 1st to 15th, 2023. Eighteen patients (10 males, 8 females; mean age: 61.2±12.0 years; range, 32 to 81 years) diagnosed with cerebral hemorrhage or cerebral infarction, confirmed by computed tomography or magnetic resonance imaging, who had hemiplegia symptoms, understood the purpose of the study, and agreed to participate voluntarily were recruited. Inclusion criteria were as follows, referring to a previous study by Tong et al.[19] a Mini-Mental State Examination score ≥21 and a Functional Ambulation Category score ≥3. Exclusion criteria were as follows: other neurological disorders that may affect one's ability to walk; additional medical or psychological conditions affecting the study process; an inability to follow two consecutive commands, or cognitive deficits; and severe contractures limiting passive range of motion in the hip, knee, or ankle joints. The study flowchart is shown in Figure 1. Written informed consent was obtained from each patient. The study protocol was approved by the Catholic University of Pusan Institutional Review Board Ethics Committee (Date: July 26, 2023, No: CUPIRB-2023-029). The study was conducted in accordance with the principles of the Declaration of Helsinki. The study

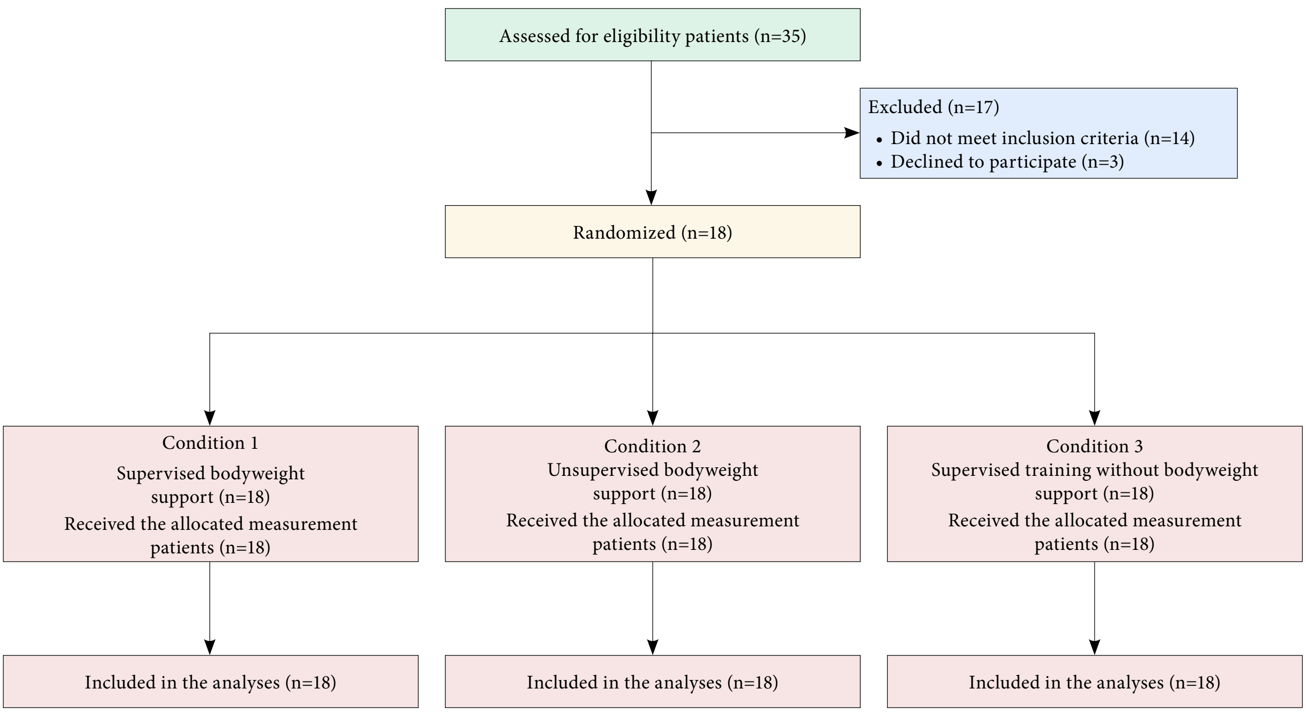

Figure 1. Study flowchart.

followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines.

The participants underwent three types of walking conditions: supervised bodyweight support (SBS), unsupervised bodyweight support (UBS), and supervised training without bodyweight support (SWBS). The participants performed each of the three conditions. The order of measurements for the three conditions was determined by having the participants roll a six-sided dice, with each gait condition represented on two sides. There was a one-day gap between the measurements for each condition.

Under conditions involving bodyweight support (SBS and UBS), measurements were performed while wearing bodyweight support gait-training equipment (Walk Mate-FCW3000, Winiz, Korea). In the condition without bodyweight support (SWBS), the test was conducted on the same course without wearing bodyweight support gait training equipment (Figure 2). In both the supervision by therapist conditions (SBS and SWBS), the therapist did not make direct contact, but walked closely beside the participants, ensuring they could be immediately protected if needed. The condition without therapist supervision was conducted without a therapist (SWBS).

Figure 2. Supervised bodyweight support.

Gait parameters (velocity, cadence, gait distance, gait cycle, stride length, step length, and single limb support) and vital signs were measured and compared using the 4-m walking test (4MWT) and 2-min walking test (2MWT). In both tests, the measurement of gait parameters used a portable wireless inertial system, G-Walk (BTS G-Walk; BTS Bioengineering Company, Garbagnate Milanese, Italy). The G-Walk device was attached using a semi-elastic belt at the waistline (fifth lumbar vertebra) with the participants in a comfortable standing position. All acceleration data were sampled at a frequency of 100 Hz, transmitted to a laptop via Bluetooth, and processed using dedicated software, BTS G-Studio (BTS G-Studio, BTS Bioengineering Company, Garbagnate Milanese, Italy). During the 2MWT, a pulse oximeter (Charm II, Charmcare, Seoul, Korea) was used to measure vital signs, including pulse rate and SpO_2.

The 4MWT measures the time a participant walks a distance of 4 m at maximum speed.[20] This test is a simple way to evaluate walking ability in clinical practice, and its inter-rater reliability had an intraclass correlation coefficient (ICC) of 0.991.[21] In this study, gait parameters were measured for a 4-m section, excluding the segments for acceleration and deceleration of 1 m each before and after a 6-m straight walking path. After three measurements, the average value was recorded, and the velocity, cadence, gait cycle, stride length, step length, and single limb support period were analyzed.

The 2MWT is an assessment modified by Butland et al.[22] from the 12-m walking test developed by McGavin et al.[23] When the examiner verbally commands “Go”, the participant walks the given route for 2 min at the fastest possible pace and is allowed to take breaks as needed. The inter-rater reliability of the 2MWT has an ICC of 0.980.[24] In this study, a 20-m track (6×4 m) was used to measure gait velocity and distance once for each condition. The pulse rate and SpO_2 were measured before and after the start of the 2MWT.

The measurements were conducted in the following order: first, a relatively low physically demanding 4MWT was performed, followed by a 5-min rest period and, then, the 2MWT was administered.

Statistical analysis

Study power analysis and sample size calculation were based on a previous study[25] using the G*Power

TABLE 1
General characteristics of the participants

	n	%	Mean±SD
Age (year)			61.2±12.0
Sex			
Male	10	55.6	
Female	8	44.4	
Height (cm)			163.50±9.36
Weight (kg)			63.89±12.72
Type of stroke			
Ischemic	12	66.7	
Hemorrhagic	6	33.3	
Duration of hemiparesis (month)			9.61±5.96
Paretic side			
Right	8	44.4	
Left	10	55.6	

SD: Standard deviation.

version 3.1.9 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany).[26] The effect size, statistical power, and alpha level were set at 0.47, 0.8, and 0.05, respectively. Based on the analysis, a sample size of 16 was calculated, and 18 participants were ultimately selected, taking into consideration a drop-out rate of 10%.

Statistical analysis was performed using the SPSS for Windows version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. The Shapiro-Wilk test was used to assess the normal distribution of the data. Paired t-tests were used to compare vital signs before and after measurement, while one-way analysis of variance was utilized to compare factors across the three gait conditions. A p value of <0.05 was considered statistically significant.

RESULTS

The analysis included 18 stroke patients with hemiparesis who performed gait tests under three conditions. The baseline characteristics of the patients are summarized in Table 1. The mean height was 163.50±9.36 cm, and the mean bodyweight was 63.89±12.72 kg. Twelve patients had an ischemic stroke, while six had a hemorrhagic stroke. The mean onset period was 9.61±5.96 months. Eight patients had right-sided paralysis, and 10 patients had left-sided paralysis (Table 1).

In the 4MWT, there were no significant differences in velocity, cadence, gait cycle, stride length, step length, or single limb support among the three conditions (p>0.05) (Table 2). In the 2MWT, however, there was a significant difference in the pulse rate and SpO_2 before and after the test in each of the three conditions (p<0.05). There were no significant differences in velocity, distance, pulse rate, or SpO_2 between the three conditions (p>0.05) (Table 3).

TABLE 2
Measurements in the 4-m walking test by condition

	SBS (n=18)	UBS (n=18)	SWBS (n=18)		
	Mean±SD	Mean±SD	Mean±SD	F	*p*
Velocity (m/s)	0.74±0.15	0.71±0.18	0.75±0.20	0.237	0.790
Cadence (step/min)	95.40±15.98	95.50±14.61	98.17±14.87	0.193	0.825
Gait cycle (s)					
Paretic	1.33±0.21	1.31±0.20	1.30±0.24	0.132	0.876
Non-paretic	1.32±0.22	1.31±0.20	1.31±0.24	0.029	0.971
Stride length (m)					
Paretic	0.96±0.20	0.91±0.18	0.95±0.23	0.340	0.713
Non-paretic	0.97±0.21	0.91±0.18	0.95±0.23	0.442	0.645
Step length (m)					
Paretic	0.49±0.13	0.47±0.09	0.48±0.11	0.156	0.856
Non-paretic	0.48±0.10	0.44±0.09	0.47±0.13	0.622	0.541
Single limb support (s)					
Paretic	0.54±0.11	0.50±0.08	0.49±0.09	1.023	0.367
Non-paretic	0.52±0.12	0.56±0.12	0.56±0.17	0.399	0.673

SBS: Supervised bodyweight support; UBS: Unsupervised bodyweight support; SWBS: Supervised training without bodyweight support; SD: Standard deviation.

TABLE 3
Measurements in the 2-minute walking test by condition

	SBS (n=18)	UBS (n=18)	SWBS (n=18)		
	Mean±SD	Mean±SD	Mean±SD	F	*p*
Velocity (m/s)	0.59±0.14	0.61±0.18	0.61±0.14	0.102	0.904
Distance (m)	70.95±17.39	73.70±21.96	72.93±17.33	0.100	0.905
Pulse rate (bit/min)					
Pre	79.72±14.50	79.56±12.32	82.78±11.92	0.353	0.705
Post	88.50±12.40	86.67±13.19	87.78±13.91	0.088	0.916
t	−5.333	−5.446	−3.425		
p	0.001*	0.001*	0.003*		
SpO_2 (%)					
Pre	96.61±3.94	96.56±2.06	96.67±1.88	0.007	0.993
Post	96.83±1.54	96.67±1.46	96.67±1.61	0.071	0.932
t	−0.308	−0.275	0.001	0.622	0.541
p	0.762	0.786	0.999		

SBS: Supervised bodyweight support; UBS: Unsupervised bodyweight support; SWBS: Supervised training without bodyweight support; SD: Standard deviation.

DISCUSSION

In the present study, we investigated the impact of therapist supervision and bodyweight support on gait parameters and vital signs during overground gait training in stroke patients. Our study results showed that there was no significant difference in various gait parameters during the 4MWT and no significant difference in velocity, distance, pulse rate, and SpO_2 during the 2MWT among the three gait conditions of SBS, UBS, and SWBS. These findings suggest that the presence of a therapist may not be essential for improving walking ability while implementing a rehabilitation program using BWSOT for stroke patients. This could be considered as an option depending on the specific application environment.

The rehabilitation of stroke patients using bodyweight support is an intervention known to improve their gait and balance abilities.[27-29] One prominent feature of the gait of stroke patients with hemiparesis is a decrease in the single limb support period of the affected limb, indicating weakness or poor balance.[30] By using bodyweight support, the single limb support period on the affected limb increases, thereby improving the temporal symmetry between both sides and enhancing balance ability.[31]

In a study by Combs et al.[32] comparing BWSTT and overground gait training, there were no significant differences in propulsion and symmetry changes. However, gait speed increased with BWSTT. This method reinforced existing asymmetric compensation strategies rather than restoring normal function, and the increase in gait speed did not translate into overground gait training.[32] Another study by Mehrholz et al.[33] reported that no significant difference between BWSTT and traditional gait training; therefore, expensive equipment such as BWSTT was not required to improve gait function in chronic stroke patients.

A Cochrane review conducted to assess the impact of treadmill training and bodyweight-supported gait training in stroke patients showed limited evidence regarding the efficacy of bodyweight-supported treadmill devices.[34] Treadmill training with or without bodyweight support showed moderate-quality evidence of improving walking speed and endurance; however, it demonstrated low-quality evidence regarding independent walking, showing no significant difference compared to other physical therapy interventions. In contrast, overground training with bodyweight support not only improved gait speed, walking endurance, lower limb function, and functional independence but also significantly increased the step length symmetry ratio.[16] This is because the participants gained a sense of stability by choosing a lower self-selected speed during ground training than during treadmill training. They felt anxious during treadmill training due to the lack of visual information and moving floor surfaces.[35] These findings suggest that it is important to consider psychological factors such as anxiety and comfort levels while designing gait training in stroke patients. By providing a stable and familiar environment, overground gait training promotes patient participation and improves rehabilitation efficiency.

Cho et al.[36] reported that two individuals walking together on flat ground walk slower than while walking alone, as they adjust their speed to match each other's speed. They found that a relatively slow partner could continuously increase their speed, resulting in benefits such as increased stamina, energy expenditure (more calories burned), and gait stability. These results support the present study, which showed that the condition with only a therapist supervision was not different, when there was only weight support and when weight support and therapist supervision were combined. Stroke patients with impaired walking function and therapists with normal walking function are presumed to have continuously adjusted their walking to synchronize their speeds unintentionally, which may have had a positive effect on relatively slow stroke patients. Furthermore, the mirror neuron network may have been activated while walking alongside the therapist. Unintentional coordination between individuals may involve the mirror neuron network, which could induce neuronal activation during action control, imitation, and motor learning through perception of others' actions (i.e., auditory, visual, tactile, or mechanical information).[37] Synchronization is more likely to occur when partners are within the visual field of the walker.[38] Therefore, patients with stroke and therapists walking together on flat ground adjust their gaits to match each other through various forms of feedback, such as auditory, visual, tactile, and others. Moreover, previous studies have suggested that this synchronization can be utilized to improve the gait patterns of patients with neurological damage.[39]

Bodyweight support and therapist supervised walking offer various benefits for gait training. However, our study did not demonstrate a synergistic enhancement when these two factors were applied together. Ideally, it would have been preferable to compare the effects of both factors by using a condition in which neither bodyweight support nor therapist-guided walking was applied. However, due to safety concerns regarding the risk of falls, this approach was not feasible in our study and our study only investigated the immediate effects and did not track the outcomes of continuous interventions. Additionally, our study had a large age range of participants, thus, differences in gait according to age could not be controlled, and due to the small number of samples, it is difficult to generalize to all stroke patients. This limitation should be noted. Notably, most bodyweight support studies have been conducted on individuals who cannot walk independently; therefore, it is expected that there would be differences in the results measured in those capable of independent walking in our study. Furthermore, in our study, a therapist was selected as the walking partner, which differs from previous studies where family members or caregivers were chosen as walking partners.

In conclusion, numerous studies support the use of bodyweight support and therapists to enhance walking function. However, no significant differences were observed when combining these two interventions. Therefore, while developing intervention plans to improve walking function in stroke patients, it is necessary to consider the effectiveness of therapist supervised walking and bodyweight support. Another interpretation is that there may be potential for improving walking in stroke patients by utilizing bodyweight support without therapist intervention. Therefore, clinicians may choose to use bodyweight support or involve therapists, depending on the clinical context, in order to enhance walking function in stroke patients. However, incorporating both conditions into an intervention may not be efficient in terms of cost, space, and personnel utilization.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, materials: C.H.P, H.H.S.; Design, control/supervision, analysis and/or interpretation, critical review: H.H.S.; Data collection and/or processing, literature review: C.H.P.; Writing the article: C.H.P, H.J.S.; References and fundings: H.J.S.

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REFERENCES

1. Thayabaranathan T, Kim J, Cadilhac DA, Thrift AG, Donnan GA, Howard G, et al. Global stroke statistics 2022. Int J Stroke 2022;17:946-56. doi: 10.1177/17474930221123175.

2. Patterson SL, Forrester LW, Rodgers MM, Ryan AS, Ivey FM, Sorkin JD, et al. Determinants of walking function after stroke: Differences by deficit severity. Arch Phys Med Rehabil 2007;88:115-9. doi: 10.1016/j.apmr.2006.10.025.
3. Schmid AA, Van Puymbroeck M, Altenburger PA, Miller KK, Combs SA, Page SJ. Balance is associated with quality of life in chronic stroke. Top Stroke Rehabil 2013;20:340-6. doi: 10.1310/tsr2004-340.
4. Park J, Kim TH. The effects of balance and gait function on quality of life of stroke patients. NeuroRehabilitation 2019;44:37-41. doi: 10.3233/NRE-182467.
5. McCullagh E, Brigstocke G, Donaldson N, Kalra L. Determinants of caregiving burden and quality of life in caregivers of stroke patients. Stroke 2005;36:2181-6. doi: 10.1161/01.STR.0000181755.23914.53.
6. Park C, Oh-Park M, Bialek A, Friel K, Edwards D, You JSH. Abnormal synergistic gait mitigation in acute stroke using an innovative ankle-knee-hip interlimb humanoid robot: A preliminary randomized controlled trial. Sci Rep 2021;11:22823. doi: 10.1038/s41598-021-01959-z.
7. Demeco A, Zola L, Frizziero A, Martini C, Palumbo A, Foresti R, et al. Immersive virtual reality in post-stroke rehabilitation: A systematic review. Sensors (Basel) 2023;23:1712. doi: 10.3390/s23031712.
8. Lim HS, Kim YL, Lee SM. The effects of Pilates exercise training on static and dynamic balance in chronic stroke patients: A randomized controlled trial. J Phys Ther Sci 2016;28:1819-24. doi: 10.1589/jpts.28.1819.
9. Swinnen E, Beckwée D, Meeusen R, Baeyens JP, Kerckhofs E. Does robot-assisted gait rehabilitation improve balance in stroke patients? A systematic review. Top Stroke Rehabil 2014;21:87-100. doi: 10.1310/tsr2102-87.
10. Mao YR, Lo WL, Lin Q, Li L, Xiao X, Raghavan P, et al. The effect of body weight support treadmill training on gait recovery, proximal lower limb motor pattern, and balance in patients with subacute stroke. Biomed Res Int 2015;2015:175719. doi: 10.1155/2015/175719.
11. Sullivan KJ, Knowlton BJ, Dobkin BH. Step training with body weight support: Effect of treadmill speed and practice paradigms on poststroke locomotor recovery. Arch Phys Med Rehabil 2002;83:683-91. doi: 10.1053/apmr.2002.32488.
12. Miller EW, Quinn ME, Seddon PG. Body weight support treadmill and overground ambulation training for two patients with chronic disability secondary to stroke. Phys Ther 2002;82:53-61. doi: 10.1093/ptj/82.1.53.
13. Mori H, Tamari M, Maruyama H. Relationship between walking ability of patients with stroke and effect of body weight-supported treadmill training. J Phys Ther Sci 2020;32:206-9. doi: 10.1589/jpts.32.206.
14. Lura DJ, Venglar MC, van Duijn AJ, Csavina KR. Body weight supported treadmill vs. overground gait training for acute stroke gait rehabilitation. Int J Rehabil Res 2019;42:270-4. doi: 10.1097/MRR.0000000000000357.
15. Park I-m, Lee Y-s, Moon B-m, Sim S-m. A comparison of the effects of overground gait training and treadmill gait training according to stroke patients' gait velocity. J Phys Ther Sci 2013;25:379-82.
16. Sousa CO, Barela JA, Prado-Medeiros CL, Salvini TF, Barela AM. The use of body weight support on ground level: An alternative strategy for gait training of individuals with stroke. J Neuroeng Rehabil 2009;6:43. doi: 10.1186/1743-0003-6-43.
17. Gama GL, Celestino ML, Barela JA, Forrester L, Whitall J, Barela AM. Effects of gait training with body weight support on a treadmill versus overground in individuals with stroke. Arch Phys Med Rehabil 2017;98:738-45. doi: 10.1016/j.apmr.2016.11.022.
18. Brunelli S, Iosa M, Fusco FR, Pirri C, Di Giunta C, Foti C, et al. Early body weight-supported overground walking training in patients with stroke in subacute phase compared to conventional physiotherapy: A randomized controlled pilot study. Int J Rehabil Res 2019;42:309-15. doi: 10.1097/MRR.0000000000000363.
19. Tong RK, Ng MF, Li LS. Effectiveness of gait training using an electromechanical gait trainer, with and without functional electric stimulation, in subacute stroke: A randomized controlled trial. Arch Phys Med Rehabil 2006;87:1298-304. doi: 10.1016/j.apmr.2006.06.016.
20. Bohannon RW, Wang YC. Four-meter gait speed: normative values and reliability determined for adults participating in the NIH toolbox study. Arch Phys Med Rehabil 2019;100:509-13. doi: 10.1016/j.apmr.2018.06.031.
21. Cabanas-Valdés R, García-Rueda L, Salgueiro C, Pérez-Bellmunt A, Rodríguez-Sanz J, López-de-Celis C. Assessment of the 4-meter walk test test-retest reliability and concurrent validity and its correlation with the five sit-to-stand test in chronic ambulatory stroke survivors. Gait Posture 2023;101:8-13. doi: 10.1016/j.gaitpost.2023.01.014.
22. Butland RJ, Pang J, Gross ER, Woodcock AA, Geddes DM. Two-, six-, and 12-minute walking tests in respiratory disease. Br Med J (Clin Res Ed) 1982;284:1607-8. doi: 10.1136/bmj.284.6329.1607.
23. McGavin CR, Gupta SP, McHardy GJ. Twelve-minute walking test for assessing disability in chronic bronchitis. Br Med J 1976;1:822-3. doi: 10.1136/bmj.1.6013.822.
24. Willi R, Widmer M, Merz N, Bastiaenen CHG, Zörner B, Bolliger M. Validity and reliability of the 2-minute walk test in individuals with spinal cord injury. Spinal Cord 2023;61:15-21. doi: 10.1038/s41393-022-00847-1.
25. Barela AMF, Sousa CO, Toledo DR, Camargo MR, Barela JA. Assessment of non-disabled individuals walking with partial body weight support over ground and on treadmill. BJMB 2015;9:31-41.
26. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175-91. doi: 10.3758/bf03193146.
27. Manning C, Pomeroy V. Effectiveness of treadmill retraining on gait of hemiparetic stroke patients: systematic review of current evidence. Physiotherapy 2003;89:337-49.
28. Hesse S. Treadmill training with partial body weight support after stroke: A review. NeuroRehabilitation 2008;23:55-65.
29. Combs-Miller SA, Kalpathi Parameswaran A, Colburn D, Ertel T, Harmeyer A, Tucker L, et al. Body weight-supported treadmill training vs. overground walking training for persons with chronic stroke: A pilot randomized controlled trial. Clin Rehabil 2014;28:873-84. doi: 10.1177/0269215514520773.

30. Chen G, Patten C, Kothari DH, Zajac FE. Gait differences between individuals with post-stroke hemiparesis and non-disabled controls at matched speeds. Gait Posture 2005;22:51-6. doi: 10.1016/j.gaitpost.2004.06.009.
31. Chen G, Patten C, Kothari DH, Zajac FE. Gait deviations associated with post-stroke hemiparesis: Improvement during treadmill walking using weight support, speed, support stiffness, and handrail hold. Gait Posture 2005;22:57-62. doi: 10.1016/j.gaitpost.2004.06.008.
32. Combs SA, Dugan EL, Ozimek EN, Curtis AB. Effects of body-weight supported treadmill training on kinetic symmetry in persons with chronic stroke. Clin Biomech (Bristol) 2012;27:887-92. doi: 10.1016/j.clinbiomech.2012.06.011.
33. Mehrholz J, Thomas S, Elsner B. Treadmill training and body weight support for walking after stroke. Cochrane Database Syst Rev 2017;8:CD002840. doi: 10.1002/14651858.CD002840.pub4.
34. Middleton A, Merlo-Rains A, Peters DM, Greene JV, Blanck EL, Moran R, et al. Body weight-supported treadmill training is no better than overground training for individuals with chronic stroke: A randomized controlled trial. Top Stroke Rehabil 2014;21:462-76. doi: 10.1310/tsr2106-462.
35. Bayat R, Barbeau H, Lamontagne A. Speed and temporal-distance adaptations during treadmill and overground walking following stroke. Neurorehabil Neural Repair 2005;19:115-24. doi: 10.1177/1545968305275286.
36. Cho H, Forster A, Christ SL, Franks MM, Richards EA, Rietdyk S. Changes to gait speed when romantic partners walk together: Effect of age and obstructed pathway. Gait Posture 2021;85:285-9. doi: 10.1016/j.gaitpost.2021.02.017.
37. Rizzolatti G, Craighero L. The mirror-neuron system. Annu Rev Neurosci 2004;27:169-92. doi: 10.1146/annurev.neuro.27.070203.144230.
38. van Ulzen NR, Lamoth CJ, Daffertshofer A, Semin GR, Beek PJ. Characteristics of instructed and uninstructed interpersonal coordination while walking side-by-side. Neurosci Lett 2008;432:88-93. doi: 10.1016/j.neulet.2007.11.070.
39. Zivotofsky AZ, Gruendlinger L, Hausdorff JM. Modality-specific communication enabling gait synchronization during over-ground side-by-side walking. Hum Mov Sci 2012;31:1268-85. doi: 10.1016/j.humov.2012.01.003.