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Title: A Systematic Review on the effects of "body-weight support gait training" in people with stroke.

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Abstract

Introduction: The use of treadmill training with body-weight support has been used in physical therapy programs for a long time. Various researches have shown the effectiveness of body-weight supported treadmill training (BWSTT) for patients after stroke, helping to improve walking speed, endurance and gait stability (Suputtitada A et al., 2004; Visintin M et al., 1998).. Currently, there are different protocols in the practical training used in clinics and hospitals.

Methods: This systematic review aims at comparing effectiveness and differences in BWSTT, and the varieties of stroke patients at a different stage. Finally, this review will try to find the subset of patients who benefits most and the clinical significance of BWSTT.

Results: In total, 12 randomized controlled trials with 1055 subjects were identified for the systematic review.

Conclusion: In clinical settings, BWSTT is recommended to be considered as an adjunct to post-stroke exercise training. Though integration with other physical therapy treatments, such as therapeutic exercise and electrical stimulation, BWSTT could make an important contribution to an improvement in walking ability as well as functional capabilities for patients after stroke.

Introduction

The prevalence of stroke is high in every country. In 2019, it was estimated that 101.5 million of people worldwide were suffered from stroke, which accounted for the second-leading cause of death in the world (AHA 2021).

In stroke rehabilitation, the focus is on regaining sufficient walking function to enable community ambulation. Therefore, it is worthy to further investigate on BWSTT, as it is a method of treatment considered particularly effective for patients after stroke, helping to improve walking speed, endurance and gait stability (Suputtitada A et al., 2004; Visintin M et al., 1998).

Objectives

In clinical and practical training, there are different protocols. This systematic review aims at comparing effectiveness and differences in BWSTT, and the varieties of stroke patients at a different stage. It also will try to find the subset of patients who benefits most and the clinical significance of BWSTT.

Methods

Inclusion and exclusion criteria and search method

In this review, I included only randomized controlled trials (RCTs). I excluded the trials if they were not published in English. I also excluded case reports and trials with no control group.

I searched the following electronic database up to September 2021: EbscoHost Medline and Pubmed. “Body weight AND stroke AND treadmill” is used as the keyword of searching. 16 Randomized Controlled Trials articles were available, with publishing years between 1996 and 2018. 12 of the articles with publishing years between 1996 and 2016 could meet the research criteria while 4 articles were excluded due to mismatch (drug efficiency, self-efficacy on balance , quality of life and study protocol).

Results

Table 1 provides general information of 12 RCT researches in categories including research title, types, focus/hypothesis and outcome measures. 7 of which included post assessments for comparison in 6-minutes walk test, walking speed and functional ambulation classification (FAC) (Nilsson L et al., 2001; Werner C et al., 2002; Suputtitada A et al., 2004; Sullivan KJ et al., 2007; Franceschini M et al., 2009; Duncan PW et al., 2011 & Srivastava A et al., 2016). 2 of them are pilot studies, provided relatively smaller sample size (Cunha Filho IT et al., 2001; Trueblood PR 2001).

BWSTT or partial-weight supported treadmill training are included in all reviews collected. Among twelve reviews, five papers evaluated on the effect of single or combined use of BWSTT with other conventional exercise program in therapy treatment sessions, while only one paper evaluated on the treatment effectiveness of BWSTT at different phase and time of stroke. (Werner C et al., 2002; Sullivan KJ et al., 2007; Duncan PW et al., 2011; Mao YR et al., 2015 & Srivastava A et al., 2016). In the remaining articles, BWSTT is compared with other treatment protocols such as exercise (Nilsson L et al., 2001), unsupported treadmill training and floor walking training (Visintin M et al., 1998; Trueblood PR 2001; Cunha Filho IT et al., 2001; Suputtitada A et al., 2004 & Franceschini M et al., 2009) and assisted overground walking (Dean CM et al., 2010).

The comparing factor for impairment in walking ability is walking speed measured in terms of a 10-meter walk and walking tolerance measured in terms of a 6-minute walk distance after analyzing outcome measures commonly used across all articles. Functional disabilities are assessed separately in 5 articles using FIM and FAC as measurements (Nilsson L et al., 2001; Cunha Filho IT et al., 2001; Werner C et al., 2002; Franceschini M et al., 2009 & Srivastava A et al., 2016).

Table 2 shows the subject-related result table, which provides the results of researches over different treatment protocols and outcome measures. Only one study showed statistical significance of using BWSTT in terms of benefits across other physiotherapy methods (Werner C et al., 2002).

5 RCTs indicated that there is significant difference using BWSTT for accelerating the rehabilitation process of people with stroke in terms of walking speed (Visintin M et al., 1998; Suputtitada A et al., 2004; Sullivan KJ et al., 2007 Dean CM et al., ; Franceschini M et al., 2009 & Dean CM et al., 2010), and 4 RCTs showed significant difference using BWSTT for increasing walking speed, gait stability , and other functional performances (Visintin M et al., 1998; Trueblood PR 2001; Suputtitada A et al., 2004 & Franceschini M et al., 2009).

Discussion

People with stroke in both acute and chronic phase were studied, as shown in table 2 . Based on the research results, all findings with BWSTT as one of the treatments, demonstrated significantly increase in gait velocity or gait endurance, required patient to receive therapy within 6 months after stroke. Late treatment does not provide extra improvement (Sullivan KJ et al., 2007). Therefore, BWSTT can still be beneficial to people with stroke in both acute and chronic phase (onset <6 months).

Furthermore, none of the studies described in those papers classified patients according to the cause of stroke, either ischemic or hemorrhagic. There are only 3 studies specified subjects as acute stroke patients (Nilsson L et al., 2001; Cunha Filho IT et al., 2001 & Werner C et al., 2002) and 2 studies labelled subjects according to the severity of stroke (Duncan PW et al., 2011 & Sullivan KJ et al., 2007). The remaining paper only stated subjects as unspecified stroke patients (Visintin M et al., 1998; Trueblood PR 2001; Suputtitada A et al., 2004 & Franceschini M et al., 2009). Therefore, additional information stratifying parameters, such as age, cause of stroke, training frequency, with larger sample size may be helpful in order to further investigate the optimal dosage and target group which can be benefited most with BWSTT.

Though all articles are RCTs, it is noted that not all RCTs have follow-up assessment to treatment effect. Hybrid treatment protocols contribute different effects. Therefore, it is controversial to set up long-term effect and prediction of treatment effectiveness using conflicting results, even if Sullivan et al (2007) showed sustained effect in a 6 month post-treatment assessment in a Level 1b, grade A RCT according to Oxford Centre for Evidence-based Practice (Tilson Jk et al., 2008).

In addition, gait analysis was also part of the potential outcomes that could be taken into consideration. Evidence has also been shown that BWSTT can enhance gait symmetry and decreased firing time in lower limb muscles (Franceschini M et al., 2009; Mao YR et al., 2015 & Trueblood PR 2001). Therefore, descriptive data on gait performance and EMG research could be an alternative outcome for future studies.

Despite the difficulty in determining how much of the improvement was related to the treatment effect or simply by self-recovery process, BWSTT should be an effective way for treating stroke and is recommended to be implemented in the rehabilitation plan.

Limitations

Three major limitations were identified from the review. Firstly, PEDro scores of literature are not considered. According to PEDro Scores range from 0 to 10, with 10 being the highest quality of RCT. Typically, PEDro scores of 6 or greater are considered high quality and sufficient to be included in a SR (Tilson JK et al., 2008). The uncertainty of PEDro score of all articles except RCT by Sullivan KJ. et al (2007) and Srivastava A. et al (2016) reduces the generalizability of the review.

Secondly, compared to other studies, the number of samples among 6 selected articles were smaller (Trueblood PR., 2001; Cunha Filho IT et al., 2001; Werner C et al., 2002; Suputtitada A et al., 2004; Mao YR et al., 2015 & Srivastava A et al., 2016). In general, the statistical power of the research can be increased by selecting research studies with larger sample size.

Lastly, the combined effects of different therapeutic options that are frequently used during BWSTT were not taken into account, for example, biofeedback therapy and electrical stimulation therapy. Due to this, the research was only focused on the differences of BWSTT and other treatments, but not to comparing the associated use of the treatment options. It is suggested that synergic effects of BWSTT and other therapeutic options could be explored for further investigations.

Conclusion

To conclude, based on the results of the selected RCTs, people with stroke were offered a better chance of recovery in walking, for example speed and distance, with BWSTT that is used at a suitable dosage. (Visintin M et al., 1998; Nilsson L et al., 2001; Werner C et al., 2002; Sullivan KJ et al., 2007; Franceschini M et al., 2009 & Duncan PW et al., 2011). There were consistently positive results reported regarding increased walking speed, endurance, thus, improved physical activity in the community.

In clinical settings, BWSTT is recommended to be considered as an adjunct to post-stroke exercise training. Though integration with other physical therapy treatments, such as therapeutic exercise and electrical stimulation, BWSTT could make an important contribution to an improvement in walking ability as well as functional capabilities for patients after stroke.

Table 1: Types and outcome measures of 12 articles

Title of article	Types of article	Research focus/hypothesis	Outcome measures
1. A comparison of regular rehabilitation and regular rehabilitation with supported treadmill ambulation training for acute stroke patients (Cunha Filho IT et al., 2001)	Randomized Controlled Trial, pilot study	1. To compare differences in motor recovery between regular rehabilitation (REG) and regular rehabilitation with supported treadmill ambulation training.	Functional Ambulatory Classification (FAC) Functional Independent Measure (FIM)
2. Treadmill walking with body weight support in subacute non-ambulatory stroke improves walking capacity more than overground walking: a randomized trial (Dean C.M. et al., 2010)	Randomized Controlled Trial	1. To find out whether treadmill walking with body weight support (BWS) during inpatient rehabilitation is detrimental to walking quality (endurance, speed, and stride length) and compared with assisted overground walking.	10 meter walk test (walking speed) 6-minut walk test (walking endurance)

3. Body-Weight–Supported Treadmill Rehabilitation after Stroke (Duncan P.W; et al., 2011)	Single blinded, Randomized Controlled Trial	1. Provision of a specialized locomotor training program which included stepping on a treadmill with body-weight support delivered early (2 months after stroke) or late (6 months after stroke), would be more effective in increasing the proportion of study participants who had higher levels in functional walking at 1 year than the provision of a control intervention that included progressive strength and balance exercises provided by a physiotherapist at home 2 months after stroke. 2. Early training in locomotion would improve walking speed more than late locomotor training.	10 meter walking speed (gait speed), 6-minute walk test (gait endurance), Berg Balance Scale
4. Walking after stroke: what does treadmill training with body weight support add to overground gait training in patients early after stroke: a single-blind, randomized controlled trial (Franceschini M. et al., 2009).	Single blinded, Randomized Controlled Trial with 6 month follow-up	1. To assess the effectiveness of gait training by using body weight support on a treadmill compared with conventional gait training for sub-acute stroke patients who were unable to walk.	Functional Ambulatory Classification (FAC) 10-meter walk test (walking speed), 6-min walk test (walking endurance), Walking handicap scale
5. The effect of body weight support treadmill training on gait recovery, proximal lower limb motor pattern & balance in patients with subacute stroke (Mao Y R et al., 2015)	Randomized Controlled Trial	1. To investigate the changes in spatiotemporal characteristics of gait after BWSTT intervention and conventional therapy (CT). 2. To investigate the impact of BWSTT on balance and lower extremity impairment when compared to CT.	Brunel balance assessment Fugl-Meyer assessment scale

6. Walking training of patients with hemiparesis at an early stage after stroke: a comparison of walking training on a treadmill with body weight support and walking training on the ground (Nilsson L et al., 2001)	Randomized Controlled Trial with 10-month follow-up	1. To compare the effect of walking training on a treadmill with body weight support (BWS) and walking training on the ground at an early stage of rehabilitation in patients with hemiparesis after stroke.	Functional Independent Measure (FIM) 10-meter walking speed (gait speed) Functional Ambulatory Classification (FAC) Berg Balance Scale
7. Body-weight-supported treadmill training for retraining gait among chronic stroke survivors: A randomized controlled study (Srivastava A et al., 2016)	Randomized Controlled Trial	1. To evaluate the effectiveness of gait training on a treadmill with & without partial body weight support for retraining gait after chronic stroke hemiparesis 2. To assess if treadmill training and BWSTT approaches are better than conventional gait training.	10-meter walking test (walking speed), 10-meter walking test (test walking endurance until the subjects cannot continue) (max. distance 320 meters) Functional Ambulatory Classification (FAC)
8. Effects of Task-Specific Locomotor and Strength Training in Adults Who Were Ambulatory After Stroke: Results of the STEPS Randomized Clinical Trial (Sullivan KJ et al., 2007)	Single Blinded, Randomized Controlled Trial, with 6 months & 12-month follow-up	1. 1. To determine whether a resisted cycling program that incorporated some of the weight-bearing and task-related demands of walking in a cyclical leg cycling task was as effective in improving walking outcomes in adults with chronic stroke who had walking disability (i.e., walking speeds at <33% of adult norms) as a high-intensity, task-specific treadmill training protocol with BWS. 2. Walking outcomes after stroke would be enhanced if a high-intensity, task-specific locomotor training program was combined with a moderately high progressive resistive LE exercise program.	10 meter walking speed (gait speed) 6-minute walk test (gait endurance)

9. Effect of partial body weight support treadmill training in chronic stroke patients (Suputtitada A; et al., 2004)	Randomized Controlled Trial	1. To compare the effect of partial body weight support treadmill training (PBWSTT) technique and floor walking training on functional balance and floor walking velocities in chronic stroke patients.	Floor walk velocities, Berg Balance Scale
10. Partial body weight treadmill training in persons with chronic stroke (Trueblood PR, 2001)	Randomized Controlled Trial, pilot study	1. Treadmill ambulation with a postural support harness would facilitate a more "normal" gait pattern in the hemiplegic patient. (More appropriate on/off patterns of muscle activity and/or any indication that improved symmetry of the lower extremities had occurred using stance and swing times)	Gait velocity Tinetti Score 6-minute walk test (gait endurance)
11. A new approach to retrain gait in stroke patients through body weight support and treadmill stimulation (Visintin M. et al., 1998)	Randomized Controlled Trial with 3 month follow-up	1. To compare the effects of gait training with body weight support (BWS) and non-body weight support (Non-BWS) on clinical outcome measures for post-stroke patients.	Berg balance scale, 10-meter walking test (walking speed), 10-meter walking test (test walking endurance until the subjects cannot continue) (max. distance 320 meters)

12. Treadmill training with partial body weight support and physiotherapy in stroke patients: a preliminary comparison (Werner C et al., 2002)	Randomized Controlled Trial, with 4-month follow-up	1. Investigation of the additive effect of conventional physiotherapy on treadmill training with body weight support (BWS).	10-meter walking speed (gait speed), Functional Ambulatory Classification (FAC)

Table 2: Subjects involved, selected Treatment protocol, result, and p-value

Number and authors of the article	Subject types and number (N)	Treatment	Chosen Outcome Measure	Results	P-value
Article 1 (Cunha Filho IT et al, 2001)	Ambulatory (>1 step) acute post-stroke patients (15)	The gait training for the STAT group was conducted, for 20 minutes, 5 days a week, by means of the body-supported treadmill ambulation system.	FAC FIM	No other significant benefits in other physiologic or functional measures (1. FAC 2. FIM) were found.	1. N/A 2. 0.53
Article 2 (Dean CM et al., 2010)	Inpatient stroke patients who were unable to walk (126)	The experimental group (n=64) undertook up to 30 minutes of treadmill walking with body weight support with an overhead harness daily, while the control group (n=62) undertook up to 30 minutes of overground walking.	Walking speed, Stride length	1. There are no significant differences between the groups of independent walkers in terms of speed or stride. 2. The independent walkers in the experimental group walked 57m further in the 6-minutes walk test than those in the control group.	Not provided by paper Not provided by paper
Article 3 (Duncan PW et al., 2011)	Moderate (54) to severe stroke (352), in 3 groups	Stepping on a treadmill with partial body-weight support and manual assistance as needed for 20 to 30 minutes at 0.89 m/s, followed by a progressive program of walking over ground for 15 minutes.	Mean walking speed Mean 6-minute walk distance	No significant differences in improvement were found between early locomotor training and home exercise.	0.83

Article 4 (Franceschini M. et al., 2009).	Non-specific stroke patients (<6 weeks) (97)	Subjects were randomly assigned to conventional rehabilitative treatment plus gait training with body weight support (BWS) on a treadmill (experimental group, n=52) and conventional treatment with overground gait training only (control group, n=45). Both groups were treated in 60-minute sessions every weekday for 4 weeks.	Functional ambulatory classification, 10-meter walk test, 6-min walk test, Walking handicap scale	1. Both groups showed improvement in all outcome measures at the end of the treatment and at follow-up. 2. No differences were seen between the 2 groups before, during, and after treatment and at follow-up.	0.0063
Article 5 (Mao YR et al., 2015)	Subjects with unilateral hemiplegia in subacute stage (24)	12 subjects received gait training with BWSTT, and 12 received conventional overground walking training (CT) for an average of 30 mins/day, 5 days/week, 4 weeks.	Functional balance, Lower extremity motor function	Both groups improved on balance & lower extremity motor function measures. In subacute patients with stroke, BWSTT can lead to improved gait quality when compared with conventional gait training.	P <0.05

Article 6 (Nilsson L et al, 2001)	First stroke (acute) patients (73)	The treatment group received walking training on a treadmill with BWS for 30 minutes, 5 days a week. According to the Motor Relearning Programme (MRP), the control group received walking training on the ground for 30 minutes 5 days a week, not including treadmill training.	10-meter walking velocity FAC FIM	There are no significant outcome differences in walking ability, balance or sensorimotor performance between walking training on a treadmill with BWS and walking training on the ground.	Not provided by paper
Article 7 (Srivastava A et al., 2016)	45 subjects with a first episode of stroke > 3months, impaired ability to walk independently	Subjects were randomly allocated to 3 groups: overground gait training, treadmill training without body-weight support and BWSTT (30 mins/day, 5 days/week, 20 sessions for 4 weeks)	10-meter walk test, FAC	Outcomes were better with BWSTT but not significant	P >0.05
Article 8 (Sullivan KJ et al., 2007)	Moderate to severe, mixed group chronic stroke patients (80)	4 sets of exercise, including 1) BWSTT, (2) limb-loaded resistive leg cycling (CYCLE), (3) LE muscle-specific progressive-resistive exercise (LEEX), and (4) LE ergometry (EX)	Comfort speed and maximum speed in 10-meter walking, 6-minute walk distance	All BWSTT groups increased walking speed and distance (1) compared to cycling, (2) whether BWSTT was combined with LE strength training or not	1. <0.004 2. <0.03

Article 9 (Suputtitada A; et al., 2004)	Non-specific chronic stroke patients (48)	Subjects in both experimental and control groups received 25 minutes of daily walking training 5 days per week, the total for 4 weeks.	Walking speed, Functional balance	1. No significant differences between both groups after a 4-week training period with regard to floor walking velocities and functional balance 2. Subjects in both groups had statistically significant improvement in floor walking velocities and functional balance after a 4-week training period when compared to before training.	Not provided by paper Not provided by paper
Article 10 (Trueblood PR, 2001)	Non-specific chronic stroke patients (13)	The intervention consisted of 6 weeks, 3X/week of a progressive postural body weight treadmill training. Week 1, the subject started at 40% body weight support and progressed over a 4 week period to 0% body weight support. They ambulated over level ground in the support harness for the last two weeks but without the unweighting.	Gait velocity	There were significant group differences at post-test for the following temporal gait variables: velocity, stride length, sound limb swing and stance time, involved initial and terminal double limb support, and total double limb support.	0.013

Article 11 (Visintin M. et al., 1998)	Non-specific stroke patients (100)	The intervention consisted of 6 weeks. 50 subjects in the experimental group were trained to walk up to 40% of their body weight supported by a BWS system with an overhead harness. The other 50 subjects in the control group were trained to walk bearing their total body weight on their lower extremities.	Functional balance, Walking speed, Walking endurance	There were significant group differences at post-test evaluation : functional balance, walking speed and walking endurance. The experimental group in the follow-up evaluation, 3-month after training, had significantly higher scores in walking speed.	Functional balance 0.001, Walking speed 0.029, Walking endurance 0.018 0.006
Article 12 (Werner C et al., 2002)	Non-ambulatory acute stroke patient (>8 weeks) (28)	Mean treadmill speed was 0.21 (range 0.15–0.30 m/s) at the beginning. After about 7 days, an average speed of 0.27 m/s was reached and kept constant until the end. The mean BWS was 27% (range 20–30) of body weight at the beginning. After an average of 14 treatment sessions, 18 subjects could walk without support, while 10 subjects needed a support of 5–15% BWS until the end. Net walking time on the treadmill was about 20 minutes per session with a brief rest in between.	FAC Gait velocity	1. 3 weeks of treadmill training with BWS plus physiotherapy accelerated the restoration of gait ability in chronic hemiparetic subjects 2. Lack of statistical effects for gait velocity and other motor functions	1. <0.001 2. N/A

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