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REVIEW ARTICLE

BODY WEIGHT-SUPPORTED GAIT TRAINING FOR RESTORATION OF WALKING IN PEOPLE WITH AN INCOMPLETE SPINAL CORD INJURY: A SYSTEMATIC REVIEW

Monique Wessels, MSc[1], Cees Lucas, PhD[2], Inge Eriks, MD[1,3] and Sonja de Groot, PhD[1,4]

From the [1]Rehabilitation Centre Amsterdam, [2]Department of Clinical Epidemiology and Biostatistics, Academic Medical Centre, University of Amsterdam, The Netherlands, [3]Swiss Paraplegic Research, Nottwil, Switzerland and [4]Centre for Human Movement Sciences, University Medical Centre Groningen, University of Groningen, The Netherlands

Objective: **To evaluate the effect of body weight-supported gait training on restoration of walking, activities of daily living, and quality of life in persons with an incomplete spinal cord injury by a systematic review of the literature.**
Methods: **Cochrane, MEDLINE, EMBASE, CINAHL, PEDro, DocOnline were searched and identified studies were assessed for eligibility and methodological quality and described regarding population, training protocol, and effects on walking ability, activities of daily living and quality of life. A descriptive and quantitative synthesis was conducted.**
Results: **Eighteen articles (17 studies) were included. Two randomized controlled trials showed that subjects with injuries of less than one year duration reached higher scores on the locomotor item of the Functional Independence Measure (range 1–7) in the over-ground training group compared with the body weight-supported treadmill training group. Only for persons with an American Spinal Injury Association Impairment Scale C or D was the mean difference significant, with 0.80 (95% confidence interval 0.04–1.56). No differences were found regarding walking velocity, activities of daily living or quality of life.**
Conclusion: **Subjects with subacute motor incomplete spinal cord injury reached a higher level of independent walking after over-ground training, compared with body weight-supported treadmill training. More randomized controlled trials are needed to clarify the effectiveness of body weight-supported gait training on walking, activities of daily living, and quality of life for subgroups of persons with an incomplete spinal cord injury.**

Key words: spinal cord injuries; gait; weight-bearing; robotics; systematic review.

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Correspondence address: Sonja de Groot, Rehabilitation Centre Amsterdam, DNO PO Box 58271, NL-1040 HG Amsterdam, The Netherlands. E-mail: s.d.groot@rcamsterdam.nl

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INTRODUCTION

A spinal cord injury (SCI) is a devastating condition with a major impact on a person's life. Incomplete or complete paralysis of the lower limbs makes walking difficult or even impossible (1) and no daily activity can be taken for granted (2).

Estimates of the incidence of SCI vary widely. An annual incidence of between 15 and 30 per million inhabitants was reported for most countries (3), with the highest incidence between 20 and 40 years of age (4). Improvement of the quality of care for persons with acute and subacute SCI has resulted in higher survival rates and relative increases in the number of persons with an incomplete SCI (1, 3, 5, 6). Currently, the average life expectancy of people with SCI was in a Canadian cohort estimated at 38 years post-injury, with 40% of individuals living with a SCI for 40 years or more (7). The relative increase in incomplete SCI and the enhanced life expectancy of people with SCI contribute to a shift of focus from prevention and cure to restoration of mobility and optimization of rest capacities (8). Restoration of mobility, which includes restoration of walking function, is also expected to improve the performance of activities of daily living (ADL) and quality of life (QoL). The decreased ability to walk is one of the consequences that people with SCI find most difficult to live with (9, 10).

In recent years, the ability of the spinal cord to heal itself and the possibility of (spontaneous) functional recovery became more widely acknowledged (1, 11). One of the ways to support or direct spontaneous recovery is task-specific gait training (1, 11). Body weight support (BWS) techniques were developed and allow for gait training, without overcompensating with spared motor function (12). BWS gait training can start before participants are able to fully bear weight, prior to developing adequate motor control, and with greater safety and less fear of falling (13). One of the BWS techniques is BWS treadmill training (BWSTT) (1). A major difficulty of BWSTT is the effort required by therapists to guide the movements of an individual's legs (1, 14). Therefore, robotic-assisted devices were developed to provide guidance in the gait training process (1). Gait training in water is another BWS gait training option (15).

Gait training techniques using partial BWS seem to be promising in restoring walking function in people with incomplete

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SCI, but the effectiveness of these techniques remains to be determined (1). The objective of this study was to evaluate the effectiveness of BWS techniques by a systematic review of published studies. Furthermore, it was investigated whether person and lesion characteristics were related to the effectiveness of different BWS training techniques and whether BWS gait training had an effect on ADL and the experienced QoL.

METHODS

Search strategy for identification of studies

The following databases were searched: Cochrane Central Register of Controlled Trials (Cochrane Library), MEDLINE (PubMed and OVID), EMBASE (OVID), Cumulative Index to Nursing and Allied Health Literature (CINAHL) through OVID, the Physiotherapy Evidence Database (PEDro) and DocOnline, a reference database of the Dutch Institute of Allied Health Professions, from 1980 (CINAHL: 1982) until September 2008. In the search strategy MeSH-terms and text words for participants (paraplegia, quadriplegia, spinal cord injuries) and interventions (gait, hydrotherapy, robotics, weight bearing, body weight support, BWS, driven gait orthosis (DGO) gait training, locomotion training, locomotor training, lokomat, robotics, treadmill, weight bearing) were combined. Two of the authors (MW and SdeG) evaluated the search strategy and the initial selection criteria on the first 100 retrieved articles. The search was conducted by the first author. Reference lists of all selected trials and retrieved reviews over the past 2 years were screened.

Inclusion of studies

Inclusion criteria were:

- *Participants:* Adults (over 18 years) with incomplete SCI classified as American Spinal Injury Association Impairment Scale (AIS) B, C or D (16).
- *Intervention:* BWS gait training of any kind, including BWS treadmill training, robotic-assisted BWS treadmill training, and gait training in water.
- *Comparison:* No intervention or conventional therapy and/or gait training without BWS techniques.
- *Outcomes:* Walking ability, ADL and QoL. Gait velocity, motor skills, and walking independence were considered indicators of walking ability, and were the outcomes of primary interest.

Randomized controlled trials (RCTs), quasi-RCTs, and controlled trials were included. Initial exploration of the literature showed that RCTs were scarce. Therefore, we also included uncontrolled trials, besides RCTs, for studies with subjects that were in the chronic phase of injury (> 1 year). A cut-off point of 1 year post-injury, after which no spontaneous recovery was expected, was chosen in agreement with the time frame used by the European Multicenter Study about Spinal Cord Injury (EMSCI) (17) and the guidelines of the International Campaign for Cures of Spinal Cord Injury Paralysis (ICCP) (18).

Exclusion of studies

The absence of a control group was a reason for exclusion of studies with participants in the subacute phase of SCI (< 1 year post-injury), because of the considerable amount of spontaneous recovery that may occur in the first year (18–20). Also excluded were trials without pre- and post-intervention data for walking-related outcomes and $n = 1$ case studies. Trials with combined interventions, for example BWSTT and functional electrical stimulation (FES), were also excluded because they were co-interventions in the evaluation of the effectiveness of the BWS intervention.

Selection procedure

An initial selection of the retrieved articles by the first author was intended to exclude obviously inappropriate articles, based on inclusion criteria and information provided in the article titles and abstracts. From this initial selection, a more specific selection was made by 2 of the authors (MW and SdeG). Thereafter, full-text articles were obtained and evaluated for in/exclusion by the 2 authors independently.

Quality assessment

Two reviewers (MW and SdeG) assessed the quality of studies independently, guided by the 19-item checklist developed by Van Tulder (21). The scale developed in 1997 (21), and not the revised scale of 2003 (22), was used to enable evaluation of non-randomized controlled trials as well. The quality of uncontrolled trials was assessed with a 14-item modified version of the 1997 list (23). Both checklists contained items for internal validity, description, and reporting of statistics. A study was considered to be of high quality (RCTs) or sufficient quality (uncontrolled trials) when for each of the domains (internal validity, description, statistics) 50% or more of the items was scored positively (23).

In order to identify and clarify potential sources of disagreement, defined (operationalized) criteria were first pre-tested on 4 selected articles.

Disagreements between the first 2 reviewers were resolved by consensus. A third reviewer (CL or IE) was consulted when consensus could not be reached or when clarification of the operationalization of criteria was required. When an article did not contain methodological information a *"no"* was scored, unless the information could be obtained from other articles by the same author. We did not contact authors for any missing data or clarifications, because the assessment of a study should not be influenced by the possibility to contact authors or their willingness to respond.

Data extraction

Two of the authors (MW and SdeG) divided the articles to be reviewed. Each extracted the data to an electronic data collection form developed for this review. Data included information on: participants (number of participants, time since injury, AIS-grade, level of injury, age), interventions (BWS technique, duration, frequency), comparisons (intervention/control group), and outcomes (walking, ADL and QoL). Each completed data extraction form was checked by the other reviewer.

Data analysis and synthesis

Agreement between reviewers on inclusion of articles and assessment of quality of included articles was assessed with kappa value (Statistical Package for Social Sciences (SPSS) version 12).

All outcome measures were based on ordinal scales or numeric scales. A quantitative synthesis and meta-analysis were undertaken, if allowed by homogeneity of data, trial design and availability of data (Review Manager 5 (http://www.cc-ims.net/Rev) Man Inverse Variance, random effects (RCTs) or fixed effect (uncontrolled trials)). A quantitative analysis was performed for uncontrolled trials of sufficient quality, which used a walking scale or walking velocity as outcome measure. Walking scales were converted into 2 nominal categories: "wheelchair bound" or "ambulatory." In order to allow cross-study comparisons of the outcome walking velocity in the uncontrolled trials, the minimal walking velocity constituting community ambulation (> 0.4 m/s) was chosen as a cut-off point (24, 25). Odds ratios were calculated for the odds to walk independently and for the odds to walk at walking velocities that constitute community ambulation pre- and post-intervention. A descriptive and best-evidence synthesis was conducted in case of clinical heterogeneity, heterogeneity of outcome measures or insufficient reported data, and for the overall weighing of the evidence. Evidence was rated from "no or insufficient evidence" to "strong evidence" (23).

RESULTS

After searching the databases, and following screening of titles and abstracts for consistency with inclusion criteria, 61 papers

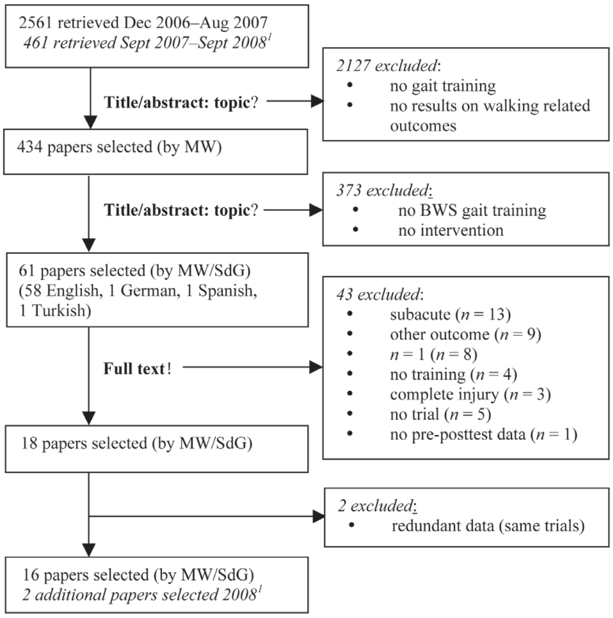


Fig. 1. Flow chart of the studies included. [1]Search Sept 2007–Sept 2008 not included in other parts of flow chart. BWS: body weight supported.

were identified as potentially relevant (Fig. 1). For 56 articles (90%) there was independent agreement about inclusion or exclusion of articles (kappa 0.79). Finally, 20 articles were left to be included in this review, of which 2 articles were excluded because they duplicated information on the same trial (Fig. 1). Two articles (13, 26) about the same RCT were included because they reported outcomes for different time frames. The update (September 2008) retrieved 461 articles, from which 2 (27, 28) were ultimately included.

Inter-agreement for the quality assessment between reviewers for the RCTs was 82% (kappa 0.75) and for the uncontrolled trials 90% (kappa 0.76). The RCTs scored 9 (29) and 15 (13, 26) out of 19 items. Of the uncontrolled studies, the median quality score was 10 (range 6–12). (A table showing quality assessment is available on request from the corresponding author.)

Description of studies

Table I summarizes all included studies. The 2 RCTs, described in 3 articles (13, 26, 29), compared therapist-assisted BWSTT with over-ground gait training programmes (13, 26, 29) and robotic-assisted BWSTT (29) for persons with a subacute SCI classified as AIS B, C or D. Of the 15 uncontrolled studies included in this review, all participants ($n = 2$–29 per study) had chronic injuries (> 1 year post-injury), mostly AIS C and D. Eleven trials evaluated therapist-assisted BWSTT (2, 27, 28, 30–37), 2 robotic-assisted BWSTT, (38, 39) 1 therapist-assisted and robotic BWSTT (40), and 1 the effectiveness of BWS gait training in water (15).

Training sessions were 3 (29–32, 34, 38) to 5 (2, 13, 15, 27, 33, 35–37, 39, 40) days per week, with a duration of 20–60 mins. The total training period varied from 1 (30, 36) to 12 months (31, 32). BWS at the start varied from 78% (29) to 30% (40) and was generally adjusted in the course of the training to maximize lower-limb loading without worsening walking kinematics (29). Walking velocity differed between the studies and increased during the training in some studies (39, 40) or kept constant in other studies (29). In 2 robotic gait training studies (39, 40) no specifics were given about the amount of guidance force. In 1 study (29) that utilized the first generation Lokomat®, only passive guidance was given. Training consisted of over-ground training alongside BWSTT as soon as participants were able to.

Walking

The meta-analysis of data from the 2 RCTs (26, 29) showed a pooled mean difference of 0.68 (95% confidence interval (CI) 0.09–1.26, $p = 0.02$), between BWSTT and over-ground training group in walking independence, measured by Functional Independence Measure locomotor (FIM-L) (1–7) after 8–12 weeks, in favour of over-ground training (Fig. 2). Subgroup analysis revealed that this difference was only significant for subjects with AIS C or D (mean difference 0.80 (95% CI 0.04–1.56), $p = 0.04$). From the 2 RCTs, there is moderate evidence that therapist-assisted-BWSTT is equivalent to over-ground training regarding walking velocity and capacity in participants with SCI of less than 1 year (13, 26, 29). Limited evidence indicated that over-ground training is more effective than therapist-assisted BWSTT to achieve walking independence as measured by FIM-L (26). No difference was observed between therapist-assisted and robotic-assisted BWSTT (29). Neither was a difference observed between groups regarding walking velocity and walking independence as measured by the Walking Index for Spinal Cord Injury (WISCI) (13, 26, 29).

For 7 uncontrolled studies (2, 27, 30, 32, 33, 36, 37), odds ratios regarding the odds to walk independently, defined by a walking scale, pre- vs post-intervention could be computed (Fig. 3). These odds ratios (OR) varied widely and were significant only in the studies of therapist-assisted BWSTT by Wernig et al., OR = 5.16 (95% CI 1.65–16.07) (36) and OR = 84.77 (95% CI 2.97–2420.04) (37). No odds ratios could be computed for community ambulation, but in 2 of the 7 uncontrolled trials community ambulation was reached as measured by speed (> 0.4 m/s (24, 25)) after therapist-assisted (35) and robotic-assisted BWSTT (39). One other study (33) reported significantly faster walking speeds without reaching community ambulation. Five of 9 uncontrolled trials reported an improvement in the percentage of participants that became independent walkers, ranging from 8% to 100% (32–34, 36–38); however, it was not clear whether community walking was achieved and whether these changes were statistically significant (Table I). In participants with chronic SCI, findings indicate that therapist-assisted BWSTT and robotic-assisted BWSTT were equally effective (40). Findings also indicate that therapist-assisted (2, 27, 28, 30-37, 40) and robotic-assisted (38-40) BWSTT for persons with chronic SCI could lead to modest gains in walking ability. Insufficient evidence was available that gait training in water improves walking parameters (15) (Table I).

Table I. *Characteristics of studies, participants and main outcomes*

Study	Design	Quality	Groups	Intervention	*n*	AIS	Level	TSI mean (SD)	Age Median (range)/ mean (SD)	Outcome	Significant results
Dobkin et al. (13)	RCT	H15	BWSTT – therapist	12 weeks, 5 days/week, 20–50 min	52	B-C	C5–L3	<8 weeks	26 (16–98)	FIM-L	=
			Overground training	12 weeks, 5 days/week, 20–50 min	57	B-C		<8 weeks	24 (16–61)	Velocity	=
			BWSTT – therapist	12 weeks, 5 days/week, 20–50 min	35	C-D		<8 weeks	36 (17–69)	WISCI	=
			Overground training	12 weeks, 5 days/week, 20–50 min	33	C-D		<8 weeks	23 (17–61)		
Dobkin et al. (26)*	RCT	H15	BWSTT – therapist	12 weeks, 5 days/week, 20–50 min	13	B	C5–L3	<8 weeks	26 (16–98)	FIM-L	↓ (C-D)
			Overground training	12 weeks, 5 days/week, 20–50 min	16	B		<8 weeks	24 (16–61)	Velocity	=
			BWSTT – therapist	12 weeks, 5 days/week, 20–50 min	43	C-D		<8 weeks	36 (17–69)	WISCI	=
			Overground training	12 weeks, 5 days/week, 20–50 min	40	C-D		<8 weeks	23 (17–61)		
Hornby et al. (29)*	RCT	L9	Overground training	8 weeks, 3 days/week, 30 min	30	B-D	C–T10	2–26 weeks	–	FIM-L	=
			BWSTT – therapist							WISCI	=
			BWSTT – robotic							LEMS	=
Effing et al. (2)*	B/A	S12	BWSTT – therapist	12 weeks, 5 days/week, 30 min	3	C-D	C5–C7	8.0 (7.5) years	48.3 (3.05)	WCS	=
Field-Fote et al. (40)[1]	B/A	S10	BWSTT – therapist	12 weeks, 5 days/week, 45–50 min	7	–	C3–C6	3.1 (2.1) years	41 (18.4)	Velocity	=
Field-Fote et al. (40)[1]	B/A	S10	BWSTT – robotic	12 weeks, 5 days/week 45–50 min	6		C4-T10	8.7 (8.4) years	43.2 (8.4)	Velocity	=
Gazzani et al. (30)*	B/A	S10	BWSTT – therapist	4–8 weeks, 3 days/week, 30 min	3	–	L1	16.3 (24.8) years	50 (10.4)	APECS	=
Giangregorio et al. (31)	B/A	S10	BWSTT – therapist	48 weeks, 3 days/week, ? min	13	B-C	C4–L1	7.4 (6.9) years	28.9 (8.4)	Modified WCS	=
Hicks et al. (32)*	B/A	S11	BWSTT – therapist	48 weeks, 3 days/week, ? min	13	B-C	C4–L1	7.4 (6.9) years	28.9 (8.4)	Modified WCS	=
Jayaraman et al. (27)*	B/A	S11	BWSTT – therapist	9–11 weeks, 5 days/weeks, 30 min	4	C-D	–	1.9 (1.0) years	46.5 (9.1)	WISCI II	=
Lucareli et al. (28)	B/A	I6	BWSTT – therapist	16 weeks, 2 days/week, 30 min	12	C-D	–	>1 years	–	Velocity	↑
Protas et al. (33)*	B/A	S11	BWSTT – therapist	12 weeks, 5 days/week, 60 min	3	C-D	T8–T11	8.7 (5.9) years	42.7 (7.6)	Garret scale of walking	=
										Velocity	↑
Stewart et al. (34)	B/A	S11	BWSTT – therapist	26 weeks, 3 days/week, ? min	9	C	C4–T12	8.1 (2.5) years	31 (3)	Modified WCS	=
Thomas & Gorassini (35)	B/A	S10	BWSTT – therapist	17 weeks, 5 days/week, 60 min	6	C-D	C3–T12	10.3 (11.9) years	58 (12.7)	WISCI II	↑
										6 min walk	↑
										Velocity	↓
Wernig et al. (36)*	B/A	S9	BWSTT – therapist	10 weeks, 5 days/week, 30 min	29	–	C–T	1–18 years (median=3)	–	WCS	↑
Wernig et al. (37)*	B/A	S9	BWSTT – therapist	10–12 weeks, 5 days/week, 30 min	8[3]	–	C4–T7	3.9 (4.5) years	44.7 (13.1)	WCS	↑
Winchester et al. (38)	B/A	S10	BWSTT – robotic	12 weeks, 3 days/week, 30 min	1	C	C5	1 years	44	WISCI II	–
					1	C	C6	4 years	49	Velocity	–
Wirz et al. (39)	B/A	S11	BWSTT – robotic	8 weeks, 5 days/week, 30 min	20	C-D	C3–L1	5.9 (4.9) years	40 (14)	Velocity	↑
Zamparo & Pagliaro (15)	B/A	S10	Water immersion walking	2 weeks, 5 days/week, 30 min	7	–	C5–T10	9.4 (4.1) years	50 (18.4)	Velocity	↑

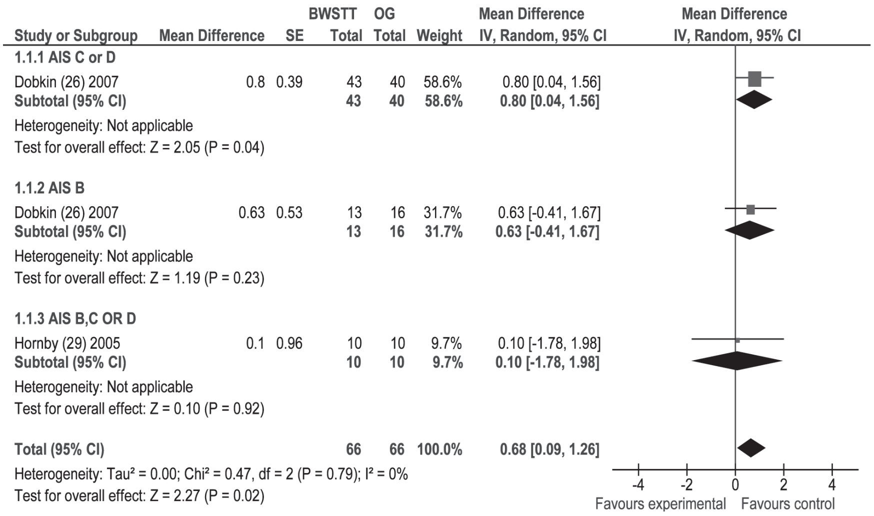
*Also included in quantitative analysis (Figs 2 and 3).

[1] RCT, but considered B/A-study for 2 arms of the trial, because all arms were body weight supported (BWS) and there were no controls without BWS. Two arms were excluded because use of functional electrical stimulation.

[3] Eight new chronic subjects compared with Wernig (36).

=: no significant change; ↑: significant increase; ↓: Significant decrease. (For RCTs between groups, B/A-studies: pre- post-test); –: unknown.

AIS: American Spinal Injury Association Impairment Scale; APECS: Adapted Patient Evaluation Conference System; B/A: before/after study; BWSTT: body weight supported treadmill training; FIM-L: Functional Independence Measure locomotor; Garret scale of walking: H: high-quality; I: insufficient quality; L: low-quality; LEMS: Lower Extremity Motor Score (0–50); n: subjects with final outcomes of interest for present review; S: sufficient quality; SD: standard deviation. TSI: time since injury; WCS: Wernig walking scale, Modified WCS (0–9); WISCI II: Walking Index for Spinal Cord Injury II.



Study or Subgroup	Mean Difference	SE	BWSTT Total	OG Total	Weight	Mean Difference IV, Random, 95% CI
1.1.1 AIS C or D						
Dobkin (26) 2007	0.8	0.39	43	40	58.6%	0.80 [0.04, 1.56]
Subtotal (95% CI)			**43**	**40**	**58.6%**	**0.80 [0.04, 1.56]**
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.05 (P = 0.04)						
1.1.2 AIS B						
Dobkin (26) 2007	0.63	0.53	13	16	31.7%	0.63 [-0.41, 1.67]
Subtotal (95% CI)			**13**	**16**	**31.7%**	**0.63 [-0.41, 1.67]**
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.19 (P = 0.23)						
1.1.3 AIS B,C OR D						
Hornby (29) 2005	0.1	0.96	10	10	9.7%	0.10 [-1.78, 1.98]
Subtotal (95% CI)			**10**	**10**	**9.7%**	**0.10 [-1.78, 1.98]**
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.10 (P = 0.92)						
Total (95% CI)			**66**	**66**	**100.0%**	**0.68 [0.09, 1.26]**
Heterogeneity: Tau² = 0.00; Chi² = 0.47, df = 2 (P = 0.79); I² = 0%						
Test for overall effect: Z = 2.27 (P = 0.02)						

Fig. 2. Forest plot of comparison: therapist-assisted body weight-supported treadmill training (BWSTT) vs over-ground training (OG). Outcome: walking independence (FIM-L, range 1–7). Data from the trial by Hornby et al. (29) and for 2 subgroups from the trial by Dobkin et al. (26). IV: inverse variance; Random: random effects (Review Manager, 5.0); AIS: American Spinal Injury Association Impairment Scale; CI: confidence interval; SE: standard error.

Subject and lesion characteristics

Participants with the greatest impairments seemed to benefit most from therapist- or robotic-assisted BWSTT gait training (32, 40), although people with AIS-grade B generally did not reach walking capability (13). Among participants who were already able to walk, robotic-assisted gait training could result in slower over-ground walking speeds (40). The time since injury seems to be inversely related to walking recovery. The greatest recovery of walking ability was seen in the studies by Wernig et al. (36, 37), with a mean time since injury of 3.9 years. The mean time since injury in the other uncontrolled trials was much longer (7.5 years) (2, 15, 27, 28, 30–35, 39, 40). Higher Lower Extremity Motor Score (LEMS) (29), FIM-L (13), and AIS-grades (13), were positive prognostic indicators for recovery of walking in participants with subacute SCI.

Activities of daily living and quality of life

The effect of BWS gait training on ADL and QoL was not measured in the retrieved RCTs (13, 29). In the studies with uncontrolled designs, insufficient evidence was found that BWS gait training affects performance of ADL (2) or QoL (2, 32).

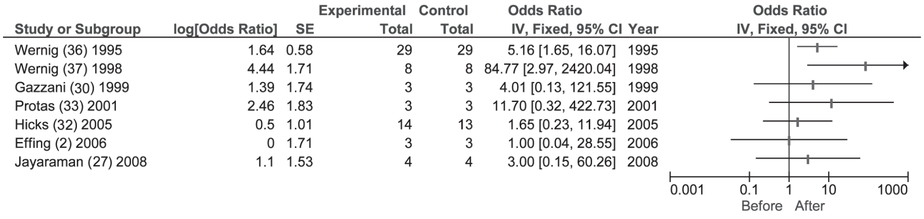
Training characteristics

No correlation was observed between frequency and duration of training and recovery of walking function. However, Dobkin et al. (13, 26) partly explained the improvement in walking ability of persons with subacute SCI by the intensity of the training, which was higher than in conventional rehabilitation.

DISCUSSION

The present systematic review of published studies found moderate evidence from 1 high-quality and 1 low-quality RCT that the effectiveness of therapist-assisted BWSTT was equivalent to over-ground gait training in restoring walking function in people with subacute incomplete SCI, regarding the outcome measures walking velocity (13, 26, 29) and independent walking as measured by WISCI (13, 26, 29). For independent walking, as measured by FIM-L, there is moderate evidence from 1 high-quality RCT that for subjects with subacute SCI classified AIS C or D, over-ground training is more effective than therapist-assisted BWSTT (26).

Our findings differ considerably from findings of previous reviews. Lam et al. (20) classified the results of the trial by Dobkin et al. (13, 26) as level 1 evidence of the effectiveness of task-specific gait training in people with SCI. Mehrholz et al. (41) concluded that BWS training did not increase the chances of walking independently (OR = 0.74, 95% CI 0.38–1.43, $p = 0.36$). Differences might be explained by the fact that our review included one more RCT in the analysis of walking-related outcomes compared with the review by Mehrholz et



Study or Subgroup	log[Odds Ratio]	SE	Experimental Total	Control Total	Odds Ratio IV, Fixed, 95% CI	Year
Wernig (36) 1995	1.64	0.58	29	29	5.16 [1.65, 16.07]	1995
Wernig (37) 1998	4.44	1.71	8	8	84.77 [2.97, 2420.04]	1998
Gazzani (30) 1999	1.39	1.74	3	3	4.01 [0.13, 121.55]	1999
Protas (33) 2001	2.46	1.83	3	3	11.70 [0.32, 422.73]	2001
Hicks (32) 2005	0.5	1.01	14	13	1.65 [0.23, 11.94]	2005
Effing (2) 2006	0	1.71	3	3	1.00 [0.04, 28.55]	2006
Jayaraman (27) 2008	1.1	1.53	4	4	3.00 [0.15, 60.26]	2008

Fig. 3. Odds ratios regarding the odds to walk independently as defined by the (adapted) Wernig Capability Scale, Wernig Scale, Garett Scale, APEC Scale or WISCI II before or after the intervention. Standard errors (SE) were obtained from 95% confidence interval (CI) of odds ratio by formula SE = (upper limit – lower limit)/3.92. (Cochrane Handbook, chapter 7.7.7.2) (42) (Review Manager, 5.0). IV: inverse variance.

al. (41). Also, we used data for the end of the training period from the trial by Dobkin et al. (13, 26) instead of data measured after 6 months. The 6-month data from Dobkin et al. (13) could not be used in the meta-analysis in the present review because data on means and SD, standard errors or CI were not available. In the review by Lam et al. (20) no forest plot was presented. In addition, both reviews were more restricted in inclusion of trial designs (RCTs only) (41) or languages (English only) (20).

Participants with subacute SCI in all training groups improved walking velocity and walking independence. Participants with the greatest impairments seemed to benefit most from BWS (32, 40). These findings might be explained by the fact that people with the greater impairments were less able to practice walking without BWS. Furthermore, when people with less impairments could also practice walking besides therapeutic interventions, persons with the most task-specific training, that is over-ground training, are likely to benefit most.

Evidence for the effectiveness of BWS gait training for persons with chronic SCI of more than one year post-injury is limited and equivocal. One possible explanation for the varied results in the group with chronic SCI is that the time since injury is a factor in the susceptibility of the injured spinal cord to stimulation by task-specific training and, thus, in the effectiveness of this training. This effect might go beyond the cut-off point for chronicity of more than one year since time of injury. Another possibility is that spontaneous recovery can occur after one year, albeit less frequently and more moderately (18). In general, large improvements in walking capacity are less to be expected among people with chronic injuries, but even small gains can make meaningful contributions to ADL (40).

It was considered important to start with over-ground training in addition to therapist- or robotic-assisted BWSTT as soon as possible (13, 29, 36, 37). Also, in robotic-assisted training, to decrease the guidance force over time was supposed to improve training effects (29). The higher intensity of training and the emphasis on task-oriented therapy are possible explanations given for the greater than expected effectiveness of over-ground gait training (13).

In both included RCTs (13, 26, 29) the effect of BWS gait training on ADL and QoL was not measured. These measurements were conducted in some of the uncontrolled trials (2, 32), but the used scales were possibly not responsive enough as a consequence of ceiling effects (2).

Although unexpected, the findings of the included trials and of the present review are not without merit, as they open the way for more RCTs to explore the relative effectiveness of different modes of gait training and training parameters.

Limitations and recommendations

A limitation of the present review might be the cut-off point of "1 year post-injury" as threshold for chronicity, because spontaneous recovery can still occur between 1 and 2 years post-injury, and even thereafter (18, 19). Another limitation is that only 2 of the included trials were RCTs, of which only one was of high quality. Fifteen included trials were uncontrolled before/after case series and were, therefore, prone to biases, such as indication bias and placebo effects. RCTs in the field of rehabilitation present a real challenge. This is especially true for evaluating interventions in SCI, due to the small and clinically heterogeneous patient group.

Comparability of results across studies should be improved by standardization of outcome measures. There are initiatives in the field of SCI rehabilitation to develop international standards and data-sets for SCI (43, 44). For assessing lower-limb function these guidelines recommend a combination of the WISCI and a quantitative timed walking test (44).

From the results of the present review, a tentative recommendation would be that gait training should begin as soon as possible after incomplete SCI, being either BWS (when necessary) or over-ground (when feasible) or both supplementary to each other. Furthermore, training at a higher intensity seems to be more effective.

In conclusion, subjects with incomplete SCI of less than one year post-injury reached a higher independency of walking (FIM-L) in the over-ground gait training group than subjects in the BWSTT group. There were no differences regarding walking velocity and ADL or QoL. Subgroup analysis revealed that this difference in FIM-L improvement was only significant for subjects with AIS C or D. For other BWS interventions or subgroup analyses, study groups were too small to draw conclusions. More RCTs are needed to clarify the effectiveness of BWS gait training on walking, ADL and QoL for subgroups of persons with incomplete SCI.

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