Treadmill training is effective for ambulatory adults with stroke: a systematic review

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Question: Does mechanically assisted walking increase walking speed or distance in ambulatory people with stroke compared with no intervention/non-walking intervention, or with overground walking? **Design**: Systematic review with meta-analysis of randomised trials. **Participants**: Ambulatory adults with stroke. **Intervention**: Mechanically assisted walking (treadmill or gait trainer) without body weight support. **Outcome measures**: Walking speed measured in m/s during the 10-m Walk Test and walking distance measured in m during the 6-min Walk Test. **Results**: Nine studies of treadmill training comprising 977 participants were included. Treadmill training resulted in faster walking than no intervention/non-walking intervention immediately after the intervention period (MD 0.14 m/s, 95% CI 0.09 to 0.19) and this was maintained beyond the intervention period (MD –0.12 m/s, 95% CI 0.08 to 0.17). It also resulted in greater walking distance immediately after the intervention period (MD 40 m, 95% CI 27 to 53) and this was also maintained beyond the intervention period (MD 40 m, 95% CI 24 to 55). There was no immediate, statistically significant difference between treadmill training and overground training in terms of walking speed (MD 0.05 m/s, 95% CI 0.12 to 0.21) or distance (MD –6 m, 95% CI –45 to 33). **Conclusion**: This systematic review provides evidence that, for people with stroke who can walk, treadmill training without body weight support results in faster walking speed and greater distance than no intervention/non-walking intervention and the benefit is maintained beyond the training period. **Review registration**: PROSPERO (CRD 42012002622). **[Polese JC, Ada L, Dean CM, Nascimento LR, Teixeira-Salmela LF (2013) Treadmill training is effective for ambulatory adults with stroke: a systematic review. *Journal of Physiotherapy* 59: 73–80]**

Key words: Stroke, Treadmill, Walking, Systematic review, Meta-analysis, Randomised controlled trials

Introduction

Although the majority of individuals achieve an independent gait after stroke, many do not reach a walking level that enables them to perform all their daily activities (Flansbjer et al 2005). Typically, the mean walking speed for the majority of community-dwelling people after stroke ranges from 0.4 m/s to 0.8 m/s (Duncan et al 1998, Eng et al 2002, Green et al 2002, Pohl et al 2002, Ada et al 2003). This slow speed frequently prevents their full participation in community activities. Additionally, people report a lack of ability to cover long distances after stroke, restricting their participation in work and social activities (Combs et al 2012). Moreover, walking ability has been found to be related to community participation (Robinson 2011).

While the goal of inpatient rehabilitation is independent and safe ambulation, once individuals return home, rehabilitation aims to enhance community ambulation skills by increasing walking speed and endurance. Lord et al (2004) found that the ability to confidently negotiate uneven terrain, private venues, malls and other public venues is the most relevant predictor of community ambulation. Therefore, in order to enhance community participation, rehabilitation has focused on identifying the best approach to optimise walking speed and walking distance. One approach to improving gait is the use of mechanically assisted walking devices, such as treadmills or gait trainers. Two Cochrane systematic reviews have examined these devices separately: Moseley et al (2005) reported on treadmill training and Mehrholz (2010) examined electromechanically-assisted training. We wanted to examine all devices that will help improve walking in the one review. In ambulatory stroke, mechanically assisted walking, whether by treadmills or gait trainers, allows an intensive amount of stepping practice by working as a 'forced use'. Mechanically assisted walking also facilitates the practice of a more normal walking pattern because it forces appropriate timing between lower limbs, promotes hip extension during the stance phase of walking and discourages common compensatory behaviours such as circumduction (Harris-Love et al 2001, Ada et al 2003, Moore et al 2010). We have already taken this approach in

What is already known on this topic: Mechanically assisted walking training, which can involve interventions such as treadmill training or electromechanical gait trainers, increases independent walking among people who have been unable to walk after stroke. However, previous systematic reviews have not drawn clear conclusions about the effect of treadmill training or gait trainers among ambulatory stroke survivors specifically.

What this study adds: Compared with no intervention or with an intervention with no walking training component, treadmill training improved walking speed and distance among ambulatory people after stroke. These benefits were maintained beyond the intervention period, but may not be greater than the effects of overground walking training.

relation to non-ambulatory stroke, where our systematic review demonstrated that mechanically assisted walking results in more independent walking (Ada et al 2010).

Therefore, this systematic review focuses on the efficacy of mechanically assisted walking for improving walking speed and distance in ambulatory people with stroke. Comparisons between mechanically assisted walking and overground walking were also examined in order to assist clinicians to decide the most appropriate intervention for adults with stroke. The specific research questions for this review were, in ambulatory people after stroke:

1. Does mechanically assisted walking result in immediate improvements in walking speed and distance compared with no intervention or a non-walking intervention?
2. Does it result in immediate improvements in walking speed and distance compared with overground walking?
3. Are any benefits maintained beyond the intervention period?

In order to make recommendations based on the highest level of evidence, this review included only randomised or quasi-randomised trials.

Box 1. Inclusion criteria.

Design
- Randomised or quasi-randomised trial

Participants
- Adults (> 18 yr)
- Stroke (> 24 hr)
- Ambulatory (Functional Ambulatory Category ≥ 3, walking speed ≥ 0.2 m/s at baseline or when the inclusion criteria stated ‘able to walk without help, with or without walking aids’ or, where mixed participants, data for ambulatory participants reported separately.)

Interventions
- Experimental. Mechanically assisted walking training (eg, treadmill training or a gait trainer) without body weight support
- Control. No intervention/non-walking intervention, or overground walking

Outcomes measured
- Walking speed
- Walking distance

Method

Identification and selection of studies

Searches for relevant studies were conducted of the following databases: Medline (1946 to April Week 1 2012, CINAHL (1986 to April Week 1 2012), EMBASE (1980 to April Week 1 2012) and PEDro (to April Week 1 2012), without language or date restrictions. Search terms included words relating to stroke, mechanically assisted walking, and locomotion (see Appendix 1 on the eAddenda for the full search strategy). In addition, we contacted authors about trials that we knew were in progress from trial registration. Titles and abstracts were displayed and screened by one reviewer to identify relevant studies. Only peer-reviewed papers were included. Full paper copies of relevant studies were retrieved and hand searching of reference lists was carried out to identify further relevant studies. The methods and abstracts of the retrieved papers were extracted so that reviewers were blinded to authors, journal, and outcomes. Two independent reviewers examined the papers for inclusion against predetermined criteria (Box 1). Conflict was resolved after discussion with a third reviewer.

Assessment of characteristics of studies

Quality: The quality of included studies was determined using PEDro scale scores extracted from the Physiotherapy Evidence Database (www.pedro.org.au). The PEDro scale rates the methodological quality of randomised trials with a score between 0 and 10 (Maher et al 2003). Where a study was not included on the PEDro database, it was scored by a reviewer following the PEDro guidelines.

Participants: Participants had to be ambulatory adults in the subacute or chronic phase after stroke. *Ambulatory* was defined as a score of at least 3 on the Functional Ambulatory Category (Holden et al 1984) or a walking speed of at least 0.2 m/s at baseline or when the included participants were able to walk without help, with or without walking aids. Studies were included when at least 80% of sample comprised ambulatory participants. Number of participants, age, time since stroke, and baseline walking speed were recorded to assess the similarity of the studies.

Intervention: The experimental intervention was mechanically assisted walking training, such as treadmill or gait trainer *without* body weight support because the participants were able to walk *a priori*. The control intervention was defined as no intervention or an intervention that did not involve walking training, ie, non-walking intervention. The experimental intervention was also compared with overground training. Session duration, session frequency, and program duration were recorded in order to assess the similarity of the studies.

Outcome measures: Two walking outcomes were of interest – speed (typically measured using 10-m Walk Test) and distance (typically measured using 6-min Walk Test). The timing of the measurements of outcomes and the procedure used to measure walking speed and distance were recorded in order to assess the similarity of the studies.

Data analysis

Data were extracted from the included studies by a reviewer and cross checked by another reviewer. Information about the method (ie, design, participants, intervention, outcome measures) and outcome data (ie, mean (SD) walking speed and walking distance) were extracted. Authors were contacted where there was difficulty with data.

The post-intervention scores were used to obtain the pooled estimate of the effect of intervention immediately (ie, post intervention) and beyond the intervention period (ie, after a period of no intervention). A fixed effects model was used. In the case of significant statistical heterogeneity ($I^2 > 50\%$), a random effects model was applied to check the robustness of the results. The analyses were performed using The MIX–Meta-Analysis Made Easy program[a] (Bax et al 2006, Bax et al 2009). The pooled data for each outcome were reported as the weighted mean difference (MD) (95% CI).

Results

Flow of studies through the review

The search returned 5305 studies. After screening the titles, abstracts and reference lists, 65 papers were retrieved for evaluation of full text. Fifty-six papers failed to meet the inclusion criteria and therefore nine papers (Pohl et al 2002, Ada et al 2003, Eich et al 2004, Weng et al 2006, Langhammer and Stanghelle 2010, Ivey et al 2011, Kuys et al 2011, Olawale et al 2011, Ada et al 2013) were included in the review. See Appendix 2 on the eAddenda for a summary of the excluded papers. Figure 1 outlines the flow of studies through the review.

Description of studies

Six randomised trials investigated the effect of mechanically assisted walking training on walking speed and walking distance, two on walking speed, and one on walking distance. The quality of the included studies is outlined in Table 1 and a summary of the studies is presented in Table 2.

Quality: The mean PEDro score of the included studies was 6.7. Randomisation was carried out in 100% of the studies, concealed allocation in 67%, assessor blinding in 67%, and intention-to-treat analysis in 44%. No studies blinded participants or therapists, due to the inherent difficulties associated with blinding physical interventions.

Participants: The mean age of participants across the studies ranged from 50 to 74 years. The mean time after stroke ranged from 1.6 to 27 months, and one study did not report this information. Participants were recruited from people living in the community in 55% of the trials.

Intervention: In all studies, the experimental group received treadmill training without body weight support. Participants undertook training for 25 to 40 min, 3–5/wk, for 2.5 to 26 wk. The control group received no intervention (three studies), a non-walking intervention (four studies), or overground walking (three studies).

Outcome measures: Walking speed was measured using the 10-m Walk Test (eight studies) and results were converted to m/s. Walking distance was measured using the 6-min Walk Test (seven studies) and results were converted to m.

Effect of intervention

Walking speed: The immediate effect of treadmill training versus no intervention or a non-walking intervention on walking speed was examined by pooling data from seven studies (Ada et al 2003, Eich et al 2004, Weng et al 2006, Ivey et al 2011, Kuys et al 2011, Olawale et al 2011, Ada et al 2013) involving 275 participants. Treadmill training increased walking speed 0.14 m/s (95% CI 0.09 to 0.19) more than no intervention/non-walking intervention (Figure 2a, see Figure 3a on the eAddenda for the detailed forest plot). The effect of treadmill training beyond the intervention period compared with no intervention/non-walking intervention on walking speed was examined by pooling data from four studies (Ada et al 2003, Eich et al 2004, Kuys et al 2011, Ada et al 2013) involving 167 participants. Treadmill training increased walking speed 0.12 m/s (95% CI 0.08 to 0.17) more than no intervention/non-walking intervention (Figure 2b, see Figure 3b on the eAddenda for the detailed forest plot).

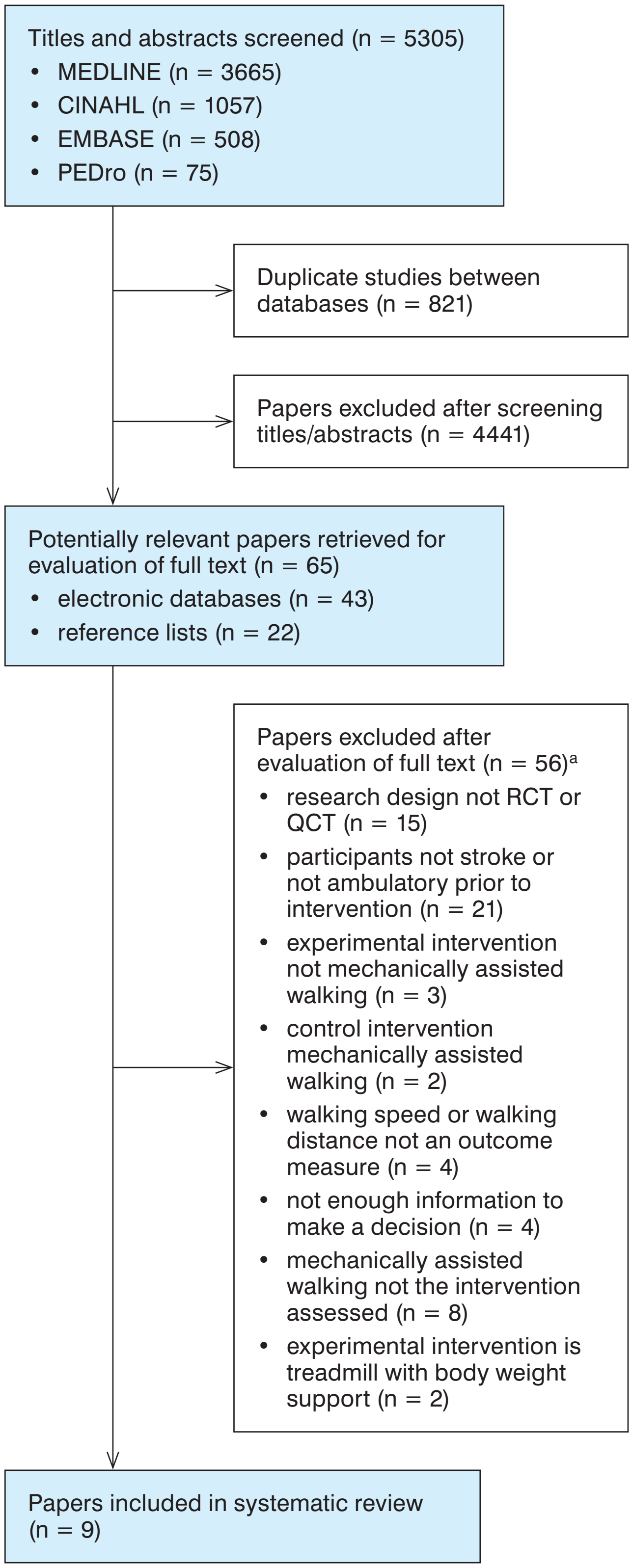


Figure 1. Flow of studies through the review. [a]Papers may have been excluded for failing to meet more than one inclusion criterion. RCT = randomised clinical trial, QCT = quasi-randomised clinical trial.

Table 1. PEDro criteria and scores for included studies (n = 9).

Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	< 15% dropouts	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
Ada et al 2003	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Ada et al 2013	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Eich et al 2004	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Ivey et al 2011	Y	N	Y	N	N	N	Y	N	Y	Y	5
Kuys et al 2011	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Langhammer & Stanghelle 2010	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Olawale et al 2011	Y	N	Y	N	N	N	Y	N	N	Y	4
Pohl et al 2002	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Weng et al 2006	Y	Y	Y	N	N	N	Y	N	Y	Y	6

Y = yes, N = no

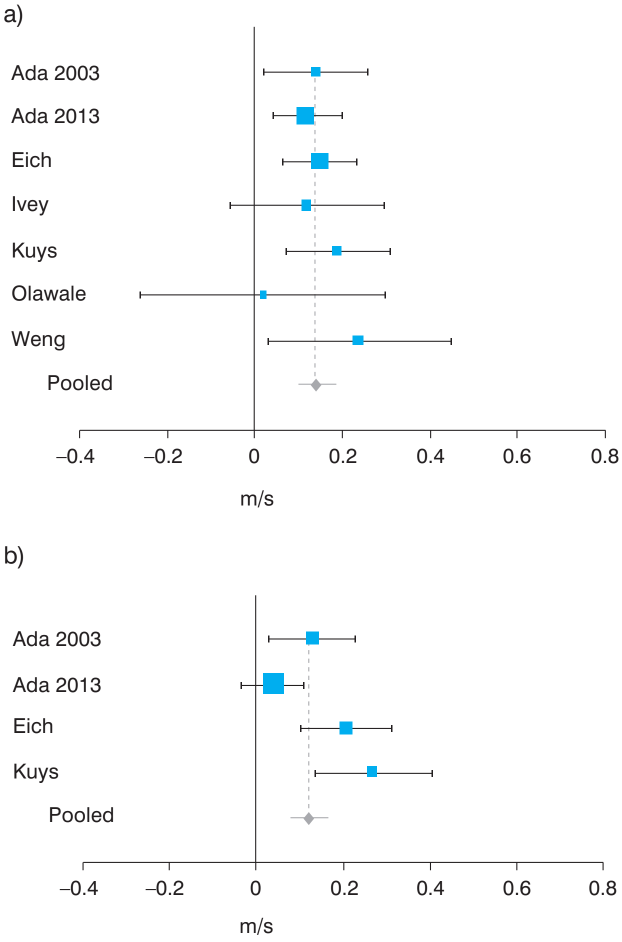


Figure 2. Mean difference (95% CI) of effect of treadmill training versus no intervention or a non-walking intervention for walking speed (m/s) a) immediately after the intervention period (n = 275) and b) beyond the intervention period (n = 167).

The immediate effect of treadmill versus overground training on walking speed was examined by pooling data from three studies (Pohl et al 2002, Langhammer and Stanghelle 2010, Olawale et al 2011) involving 119 participants. There was no significant difference in walking speed between treadmill training and overground training (MD 0.05 m/s, 95% CI –0.12 to 0.21) (Figure 4, see Figure 5 on the eAddenda for a detailed forest plot). No studies measured the effect of treadmill training versus overground walking on walking speed beyond the intervention period.

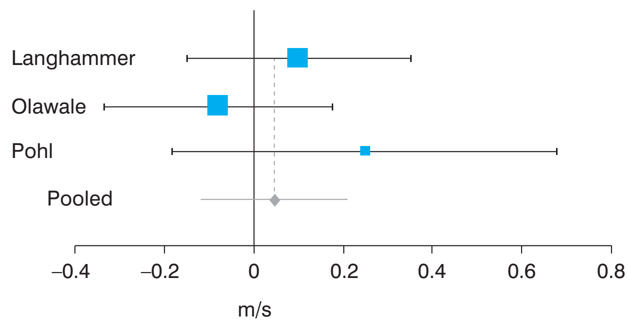


Figure 4. Mean difference (95% CI) of effect of treadmill training versus overground for walking speed (m/s) immediately after the intervention period (n = 119).

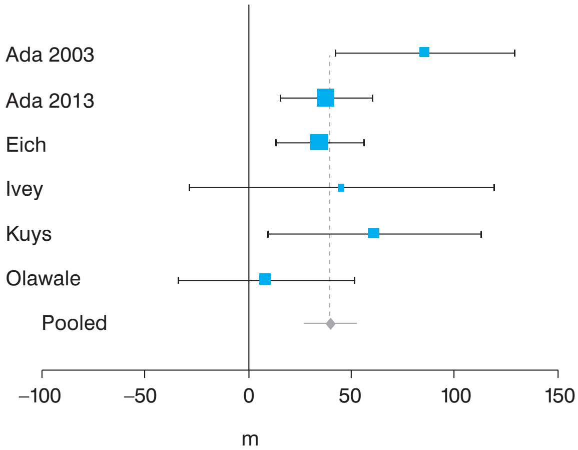
Table 2. Summary of included studies (n = 9).

Study	Design	Participants	Intervention	Outcome measures
Ada et al 2003	RCT	n = 29 Age (yr) = 66 (SD 12) Time since stroke (months) = 27 WS = Exp: 0.62 (SD 0.24); Con: 0.53 (SD 0.30)	Exp = TM 30 min x 3/wk x 4 wk Con = NW (strength, co-ord, balance) 30 min x 3/wk x 4 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 4, 16 wk
Ada et al 2013	RCT	n = 102 Age (yr) = 67 (SD 12) Time since stroke (months) = 21 WS = Exp1: 0.51 (SD 0.27); Exp2: 0.49 (SD 0.29); Con: 0.50 (SD 0.24)	Exp = TM 30 min x 3/wk x 8 wk Con = no intervention	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 16, 26 wk
Eich et al 2004	RCT	n = 50 Age (yr) = 63 (SD 5) Time since stroke (months) = 1.6 WS = Exp: 0.40 (SD 0.17); Con: 0.44 (SD 0.22)	Exp = TM 30 min x 5/wk x 6 wk Con = no intervention Both = OG 30 min x 5/wk x 6 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 6, 18 wk
Ivey et al 2011	RCT	n = 38 Age = 61 (SD 9) Time since stroke (months) = not reported WS = Exp: 0.54 (SD 0.27); Con: 0.49 SD (0.27)	Exp = TM 40 min x 3/wk x 26 wk Con = NW (stretch) 40 min x 3/wk x 26 wk	Distance = 6-min walk test Timing: 0, 26 wk
Kuys et al 2011	RCT	n = 30 Age (yr) = 68 (SD16) Time since stroke (months) = 1.7 WS = Exp: 0.34 (SD 0.20); Con: 0.58 (SD 0.36)	Exp = TM 30 min x 3/wk x 6 wk Con = no intervention Both = usual care 60 min x 3/wk x 6 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 6, 18 wk
Langhammer and Stanghelle 2010	RCT	n = 39 Age (yr) = 74 (SD 12) Time since stroke (months) = 12 WS = Exp: 0.8 (SD 0.5); Con: 0.8 (SD 0.4)	Exp = TM 30 min x 5/wk x 2.5 wk Con = OG 30 min x 5/wk x 2.5 wk Both = usual care 170 min x 5/wk x 2.5 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 2.5 wk
Olawale et al 2011	RCT	n = 60 Age (yr) = 56 (SD 6) Time since stroke (months) = 10 WS = Exp1: 0.36 (SD 0.95); Exp2: 0.39 (SD 1.19); Con: 0.39 (SD 0.90)	Exp = TM 25 min x 3/wk x 12 wk Con1 = OG 25 min x 3/wk x 12 wk Con2 = NW (stretch, strength, balance) 25 min x 3/wk x 12 wk All = usual care 35 min x 3/wk x 12 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 12 wk
Pohl et al 2002	RCT	n = 60 Age (yr) = 59 (SD 11) Time since stroke (months) = 4 WS = Exp: 0.61 (SD 0.32); Con: 0.66 (SD 0.42)	Exp = TM 30 min x 3/wk x 4 wk Con = OG 45 min x 2/wk x 4 wk Both = usual care 45 min x 2/wk x 4 wk	Speed = 10-m walk test Timing: 0, 4 wk
Weng et al 2006	RCT	n = 26 Age (yr) = 50 (SD 13) Time since stroke (months) = 2 WS = Exp: 0.53 (SD 0.33); Con: 0.55 (SD 0.28)	Exp = TM 30 min x 5/wk x 3 wk Con = NW (exercise, stepping) 30 min x 5/wk x 3 wk Both = usual care 30 min x 5/wk x 3 wk	Speed = 10-m walk test Timing: 0, 3 wk

RCT= randomised controlled trial, WS = walk speed at baseline (m/s), Exp = experimental group, Con = control group, TM = treadmill walking, OG = overground walking, NW = non-walking intervention.

Walking distance: The immediate effect of treadmill training versus no intervention or a non-walking intervention on walking distance was examined by pooling data from six studies (Ada et al 2003, Eich et al 2004, Ivey et al 2011, Kuys et al 2011, Olawale et al 2011, Ada et al 2013) involving 249 participants. Treadmill training increased walking distance 40 m (95% CI 27 to 53) more than no intervention/non-walking intervention (Figure 6a, see Figure 7a on the eAddenda for the detailed forest plot). The effect of treadmill training versus no intervention/non-walking intervention on walking distance beyond the intervention period was examined by pooling data from four studies (Ada et al 2003, Eich et al 2004, Kuys et al 2011, Ada et al 2013) involving 167 participants. Treadmill training increased walking distance 40 m (95% CI 24 to 55) more than no intervention/non-walking intervention (Figure 6b, see Figure 7b on the eAddenda for the detailed forest plot).

a)



b)

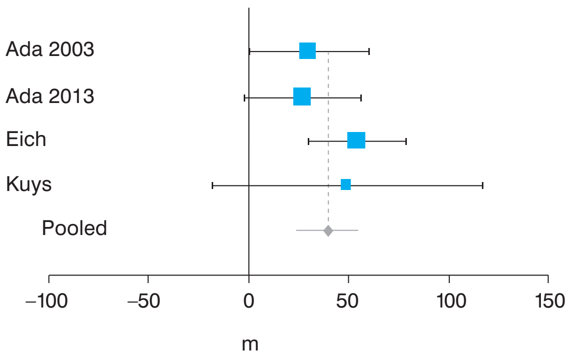


Figure 6. Mean difference (95% CI) of effect of treadmill training versus no intervention/non-walking intervention for walking distance (m) a) immediately after the intervention period (n = 249) and b) beyond the intervention period (n = 167).

The immediate effect of treadmill training versus overground on walking distance was examined by pooling data from two studies (Langhammer and Stanghelle 2010, Olawale et al 2011) involving 79 participants. There was no statistical difference in walking distance between treadmill training and overground training (MD –6 m, 95% CI –45 to 33) (Figure 8, see Figure 9 on the eAddenda for the detailed forest plot). No studies measured the effect of treadmill training versus overground walking on walking distance beyond the intervention period.

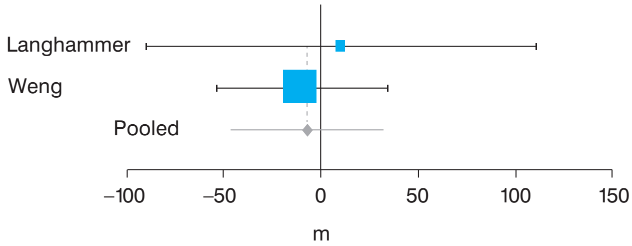


Figure 8. Mean difference (95% CI) of effect of treadmill training versus overground for walking distance (m) immediately after the intervention period (n = 79).

Discussion

This review provides evidence that treadmill training without body weight support is effective at improving walking in people who are ambulatory after stroke. Furthermore, the benefits appear to be maintained beyond the intervention period. However, whether treadmill training is more beneficial than overground training is not known.

Meta-analysis indicated that treadmill training produced benefits in terms of both walking speed and distance. Treadmill training produced 0.14 m/s faster walking and 40 m greater distance than no intervention/non-walking intervention immediately after intervention and these benefits were maintained beyond the intervention period. This effect is likely to be a conservative estimate of the effect of treadmill training, since some of the non-walking interventions given to the control group (such as strengthening) may have had some effect on walking. Importantly, these benefits appear to be clinically meaningful. For example, Tilson et al (2010) demonstrated that a between-group difference in walking speed after stroke of 0.16 m/s resulted in a 1-point improvement in the modified Rankin scale. Furthermore, there is no indication that the effect of treadmill training is different when carried out with subacute stroke undergoing hospital-based rehabilitation or with chronic stroke after discharge from formal rehabilitation. This may be because the length and frequency of treadmill training sessions delivered was similar across studies (mean length 30 min, SD 4; mean frequency 4/wk, SD 1) despite the variation in duration of training program (mean duration 9 wk, SD 7).

There are insufficient data to provide evidence as to whether treadmill training is better than overground training. Only three studies (Pohl et al 2002, Langhammer and Stanghelle 2010, Olawale et al 2011) investigating this question were found. Meta-analysis indicates no significant difference between treadmill training and overground training for both walking speed and distance. However, the confidence intervals are wide and include worthwhile effects in both cases, suggesting that further studies are necessary to answer this question.

Although we sought trials of any type of mechanically assisted walking training, all of the studies included in this review examined treadmill training. A previous Cochrane systematic review of treadmill training (Moseley et al 2005) concluded that it did not have a statistically significant effect on walking speed (three studies) or distance (one study) compared with any other physiotherapy intervention in people who could already walk after stroke. Neither did treadmill training have a statistically significant effect on walking speed or distance when combined with other task-specific training (three studies). The inclusion of nine studies in the current meta-analysis is probably the main reason that our review came to a different conclusion.

This review has both limitations and strengths. A source of bias in the studies included in this review was lack of blinding of therapist and patients, since it is not possible to blind the therapist or the participants during the delivery of complex interventions. Another source of bias was lack of reporting whether an intention-to-treat analysis was undertaken. The number of participants per group (mean 21, SD 7.5) was quite low, opening the results to small trial bias. Only four of the nine included studies measured the outcomes after the cessation of intervention, which meant that the maintenance of the effect of intervention could not be evaluated well. In spite of these shortcomings, the mean PEDro score of 6.7 for the trials included in this review represents high quality. Another strength, unusual in rehabilitation studies, was that the outcome measures were the same, with walking speed always measured using the 10-m Walk Test and walking distance measured using the 6-min Walk Test. Finally, publication bias inherent to systematic reviews was avoided by including studies published in languages other than English.

This systematic review provides evidence that treadmill training without body weight support results in faster walking speed and greater distance than no intervention/non-walking intervention, both immediately after intervention and beyond the intervention period. Clinicians should therefore be confident in prescribing treadmill training for ambulatory stroke individuals when the primary objective of rehabilitation is to improve walking speed and distance, regardless of whether the individuals are at the subacute or chronic stage of their recovery. The parameters of gait training, such as speed, duration, and treadmill inclination, can be tailored to individuals to ensure training is challenging and to provide motivating feedback about the distance walked and the amount of work performed. ■

Footnotes: [a]The MIX–Meta-Analysis Made Easy program Version 1.7. http://www.meta-analysis-made-easy.com/

eAddenda: Appendix 1 and 2, and Figures 3a and 3b, 5, 7a and 7b, and 9, available at jop.physiotherapy.asn.au

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References

Ada L, Dean CM, Hall JM, Bampton J, Crompton S (2003) A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomised trial. *Archives of Physical Medicine & Rehabilitation*. 84: 1486–1491.

Ada L, Dean CM, Lindley R (2013) Randomized trial of treadmill training to improve walking in community-dwelling people after stroke: the AMBULATE trial. *International Journal of Stroke* doi: 10.1111/j.1747-4949.2012.00934.x.

Ada L, Dean CM, Vargas J, Ennis S (2010) Mechanically assisted walking with body weight support results in more independent walking than assisted overground walking in non-ambulatory patients early after stroke: a systematic review. *Journal of Physiotherapy* 56: 153–161.

Bax L, Yu LM, Ikeda N, Tsuruta H, Moons KG (2006) Development and validation of MIX: comprehensive free software for meta-analysis of causal research data. *BMC Medical Research Methodology* 13: 50.

Bax L, Ikeda N, Fukui N, Yaju Y, Tsuruta H, Moons KG (2009) More than numbers: the power of graphs in meta-analysis. *American Journal of Epidemiology* 169: 249–255.

Combs SA, Van Puymbroeck M, Altenburger PA, Miller KK, Dierks TA, Schmid AA (2012) Is walking faster or walking farther more important to persons with chronic stroke? *Disability & Rehabilitation* 5. [Epub ahead of print]

Duncan P, Richards L, Wallace D, Stoker-Yates J, Pohl P, Luchies C, et al (1998) A randomised, controlled pilot study of a home-based exercise program for individuals with mild and moderate stroke. *Stroke* 29: 2055–2060.

Eich HJ, Mach H, Werner C, Hesse S (2004) Aerobic treadmill plus Bobath walking training improves walking in subacute stroke: a randomised controlled trial. *Clinical Rehabilitation* 18: 640–651.

Eng JJ, Chu KS, Dawson AS, Kim MC, Hepburn KE (2002) Functional walk tests in individuals with stroke: relation to perceived exertion and myocardial exertion. *Stroke* 33: 756–761.

Flansbjer UB, Holmbäck AM, Downham D, Patten C, Lexell J (2005) Reliability of gait performance tests in men and women with hemiparesis after stroke. *Journal of Rehabilitation Medicine* 37: 75–82.

Green J, Forster A, Bogle S, Young J (2002) Physiotherapy for patients with mobility problems more than 1 year after stroke: a randomised controlled trial. *Lancet* 359: 199–203.

Harris-Love ML, Forrester LW, Macko RF, Silver KH, Smith GV (2001) Hemiparetic gait parameters in overground versus treadmill walking. *Neurorehablitation and Neural Repair* 15: 105–112.

Holden MK, Gill KM, Magliozzi MR, Nathan J, Piehl-Baker L (1984) Clinical gait assessment in the neurologically impaired. Reliability and meaningfulness. *Physical Therapy* 64: 35–40.

Ivey FM, Ryan AS, Hafer-Macko CE, Macko RF (2011) Improved cerebral vasomotor reactivity after exercise training in hemiparetic stroke survivors. *Stroke* 42: 1994–2000.

Kuys SS, Brauer SG, Ada L (2011) Higher-intensity treadmill walking during rehabilitation after stroke is feasible and not detrimental to walking pattern or quality: a pilot randomised trial. *Clinical Rehabilitation* 25: 316–326.

Langhammer B, Stanghelle JK (2010) Exercise on a treadmill or walking outdoors? A randomised controlled trial comparing effectiveness of two walking exercise programmes late after stroke. *Clinical Rehabilitation* 24: 46–54.

Lord SE, McPherson KM, McNaugton HK, Rochester L, Weatherall M (2004) Community ambulation following stroke: how important and obtainable is it, and what measures appear predictive? *Archives of Physical Medicine & Rehabilitation* 85: 234–239.

Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M (2003) Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical Therapy* 83: 713-721.

Mehrholz J, Werner C, Kugler J, Pohl M (2010) Electromechanical-assisted training for walking after stroke. *Cochrane Database of Systematic Reviews* 4: CD006185.

Moore JL, Roth EJ, Killian C, Hornby TG (2010) Locomotor training improves daily stepping activity and gait efficiency in individuals poststroke who have reached a 'plateau' in recovery. *Stroke* 41: 129–135.

Moseley AM, Stark A, Cameron ID, Pollock A (2005) Treadmill training and body weight support for walking after stroke. *Cochrane Database of Systematic Reviews* 4: CD002840.

Olawale OA, Jaja SI, Anigbogu CN, Appiah-Kubi KO, Jones-Okai D (2011) Exercise training improves walking function in an African group of stroke survivors: a randomised controlled trial. *Clinical Rehabilitation* 25: 442–450.

Pohl M, Mehrholz J, Ritschel C, Rückriem S (2002) Speed-dependent treadmill training in ambulatory hemiparetic stroke patients: a randomised controlled trial. *Stroke.* 33: 553–558.

Robinson CA, Shumway-Cook A, Matsuda PN, Ciol MA (2011) Understanding physical factors associated with participation in community ambulation following stroke. *Disability & Rehabilitation.* 33: 1033–1042.

Tilson JK, Sullivan KJ, Cen SY, Rose DK, Koradia CH, Azen SP, et al (2010) Meaningful gait speed improvement during the first 60 days poststroke: minimal clinically important difference. *Physical Therapy* 90: 196–208.

Weng CS, Wang J, Pan XY, Yu ZZ, Wang G, Gao LP, et al (2006) [Effectiveness of backward walking treadmill training in lower extremity function after stroke]. *Zhonghua Yi Xue Za Zhi* 86: 2635–2638.

