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

Louise Ada, Catherine M Dean, Janine Vargas and Samantha Ennis

The University of Sydney, Australia

Question: Does mechanically assisted walking with body weight support result in more independent walking and is it detrimental to walking speed or capacity in non-ambulatory patients early after stroke? **Design**: Systematic review with meta-analysis of randomised trials. **Participants**: Non-ambulatory adult patients undergoing inpatient rehabilitation up to 3 months after stroke. **Intervention**: Mechanically assisted walking (eg, treadmill, electromechanical gait trainer, robotic device, servo-motor) with body weight support (eg, harness with or without handrail, but not handrail alone) versus assisted overground walking of longer than 15 min duration. **Outcome measures**: The primary outcome was the proportion of participants achieving independent walking. Secondary outcomes were walking speed measured as m/s during the 10-m Walk Test and walking capacity measured as distance in m during the 6-min Walk Test. **Results**: Six studies comprising 549 participants were identified and included in meta-analyses. Mechanically assisted walking with body weight support resulted in more people walking independently at 4 weeks (RD 0.23, 95% CI 0.15 to 0.30) and at 6 months (RD 0.23, 95% CI 0.07 to 0.39), faster walking at 6 months (MD 0.12 m/s, 95% CI 0.02 to 0.21), and further walking at 6 months (MD 55 m, 95% CI 15 to 96) than assisted overground walking. **Conclusion**: Mechanically assisted walking with body weight support is more effective than overground walking at increasing independent walking in non-ambulatory patients early after stroke. Furthermore, it is not detrimental to walking speed or capacity and clinicians should therefore be confident about implementing this intervention. **[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]**

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

Introduction

After stroke, many individuals have residual walking disability. Despite recent advances in medical and rehabilitation sciences, only half of those who cannot walk on entering rehabilitation after stroke regain the ability to walk (Dean and Mackey 1992). Being able to walk independently is a major determinant of whether an individual returns home following a stroke and has long lasting implications for the person's quality of life and ability to participate in activities of daily living.

For non-ambulatory stroke patients, mechanically assisted walking with body weight support has been suggested as a strategy to facilitate walking (Hesse 1998, Richards et al 1993) because it provides the opportunity to complete more practice of the whole task than would be possible by assisting overground walking. A Cochrane Review (Moseley et al 2005) found no statistically significant difference between treadmill walking with body weight support when compared with any other walking intervention in terms of amount of independent walking, walking speed, or walking capacity. The main conclusion from this review was an urgent need for well-designed large-scale studies to evaluate the effects of treadmill walking and body weight support on walking after stroke. Since then, more large scale trials have been completed. The inconclusive result of the Cochrane review could be partially the result of comparing treadmill walking with other mechanised walking (such as an electromechanical gait trainer) which may be expected to result in even more practice than treadmill walking. A systematic review examining electromechanical gait trainers only (Mehrholz et al 2010) found an increase in the likelihood of walking. We therefore planned a systematic review focusing broadly on any mechanically assisted walking, and comparing it with overground walking so that therapists and health administrators would have evidence to help guide decision making in terms of investing in mechanical walking equipment. In particular, we were interested in whether any benefits of mechanically assisted walking were still apparent in the long term or whether the effect was short lived.

Clinicians still seem reluctant to implement treadmill training for stroke patients due to a fear that an abnormal walking pattern will be practised (Hesse 2008) resulting in abnormal overground walking (Davies 1999). We were therefore interested in examining any aspects of walking commonly measured, such as speed and capacity, which would shed some light on whether this fear is reasonable. The specific research questions for this review were:

1. In subacute, non-ambulatory patients after stroke, does mechanically assisted walking with body weight support result in more independent walking than overground walking in the short term?
2. Is it detrimental in terms of walking speed or capacity?

3. Are any benefits maintained in the long term?

In order to make recommendations based on the highest level of evidence, this review included only randomised or quasi-randomised trials in which patients undergoing inpatient stroke rehabilitation to enable them to walk were randomised to receive either mechanically assisted walking with body weight support or assisted overground walking.

Method

Identification and selection of studies

Searches were conducted of the following databases: MEDLINE (1966 to August Week 4 2009), CINAHL (1982 to August Week 4 2009), EMBASE (1980 to August Week 4 2009) and PEDro (to August Week 4 2009), without language restrictions for relevant articles. Search terms included words relating to stroke, exercise therapy, 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. Title and abstracts were displayed and screened by one reviewer to identify relevant studies. Full paper copies of relevant studies were retrieved and their reference lists were screened. The methods of retrieved papers were extracted so that reviewers were blinded to authors, journals and outcomes and examined against predetermined inclusion criteria (Box 1) by two independent reviewers. Conflict of opinion was resolved by consensus after discussion with a third reviewer.

Box 1. Inclusion criteria.

Design
- RCT or Q-RCT
- PEDro Scale score > 4

Participants
- Adults (> 18 year)
- Stroke patients (> 24 hr)
- Subacute (≤ 3 months after stroke)
- Non-ambulatory (FAC < 3 [0-5], FIM < 5 [1–7]) or where mixed participants, data for non-ambulatory patients reported separately

Intervention
- Experimental group received mechanically assisted walking with body weight support > 15 min
- Control group received assisted overground walking > 15 min

Outcomes measured
- Independent walking (measured as proportion or scale from which proportion could be determined)

Comparisons
- Mechanically assisted walking with body weight support vs overground walking
- Mechanically assisted walking with body weight support + assisted overground walking vs overground walking

RCT = randomised clinical trial, Q-RCT = quasi-randomised clinical trial, FAC = Functional Ambulation Category, FIM = Functional Independence Measure

Assessment of characteristics of studies

Quality: The quality of included studies was determined by obtaining PEDro scale scores from the Physiotherapy Evidence Database (www.pedro.org.au). The PEDro scale rates the methodological quality of randomised trials between 1 and 10. The score is determined by two independent raters, with a third rater resolving any disagreements. Where a study was not included on the database, the PEDro scale was scored by two reviewers independently with disagreements resolved by a third reviewer.

Participants: Studies involving subacute, non-ambulatory, adult stroke survivors were included. Subacute was defined as within the first three months following stroke. Non-ambulatory was defined as Functional Ambulatory Category < 3 (Holden et al 1984), Functional Independence Measure (Keith et al 1987) walking subscale score < 5, Item 5 Motor Assessment Scale score < 2, or equivalent. Even so, in many trials, the ambulation status of the participants at baseline was not clear. Therefore, the measurement of independent walking as an outcome was used as an inclusion criterion in order to confirm that the trial investigated participants who were non-ambulatory at baseline.

Intervention: The experimental intervention was any type of mechanically assisted walking (such as treadmill, electromechanical gait trainer, robotic device or servo-motor) with body weight support (provided by a harness system, with or without handrail, but not handrail alone) regardless of the amount of therapist assistance. The control intervention was overground walking and could include any type of assistance from therapists or aids (such as orthoses or sticks). Training was required to be of a duration that could be expected to improve walking, ie, > 15 minutes per session.
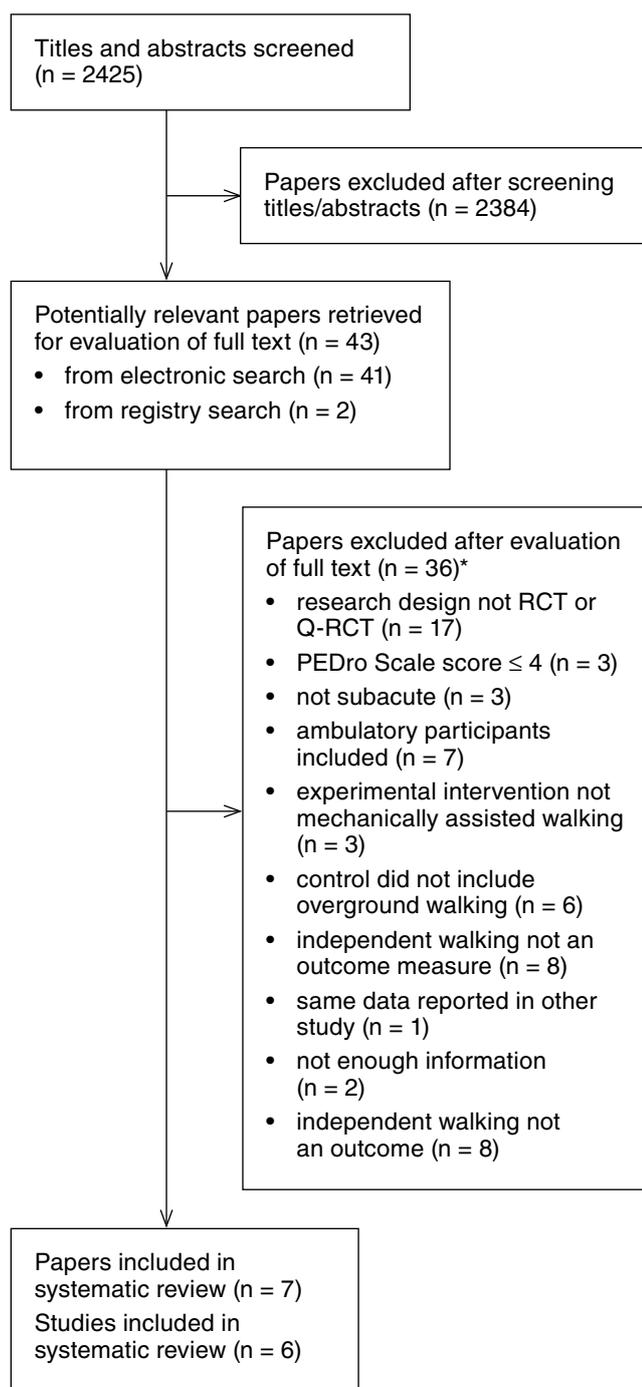
Outcome measures: The amount of independent walking was the primary outcome measure. Independent walking was defined as being able to walk without aids or physical assistance (ie, Functional Ambulatory Category ≥ 3 or equivalent).

Secondary outcomes were walking speed and walking capacity. Walking speed was measured in m/s during any short distance test (such as the 10-m Walk Test, Wade et al 1987). Walking capacity was measured as distance walked in m during a longer timed test (such as the 2-, 5-, 6- or 12-min Walk Test) and converted to the equivalent of a 6-min Walk Test (Guyatt et al 1984). For both secondary outcomes, only data from participants who could walk independently were used.

Data analysis

Data were extracted from the included studies by one reviewer and cross-checked by a second reviewer. Information about the method (ie, design, participants, intervention, measures) and outcome data (ie, number of participants who could walk independently, mean (SD) walking speed, and walking capacity) were extracted. Authors were contacted where there was difficulty extracting and interpreting data from the paper.

The post-intervention scores were used to obtain the pooled estimate of the effect of intervention at 4 weeks (short term) and 6 months (long term). A fixed-effects model was used. In the case of significant statistical heterogeneity ($I^2 > 25\%$), a random-effects model was applied to check the robustness of the results. The analyses were performed using the MIX[a] program (Bax et al 2006, Bax et al 2008). Dichotomous outcomes (ie, amount of independent walking) were reported as risk difference (95% CI) whereas continuous

Du et al 2006, Schwartz et al 2009, Tong et al 2006) were included in the review. One trial was reported across two publications (Ada et al 2010, Dean et al 2010), so the seven included papers provided data on six studies. See Figure 1 for flow of studies through the review. See Table 1 for a summary of the excluded papers (see eAddenda for Table 1).

Description of studies

Six randomised trials investigated the effect of mechanically assisted walking on independent walking. Five trials investigated the effect on walking speed. Two trials investigated the effect on walking capacity. The quality of the included studies is outlined in Table 2 and a summary of the studies is presented in Table 3.

Quality: The mean PEDro score of the included studies was 6.7. Randomisation was carried out in 100% of the studies, concealed allocation in 33%, assessor blinding in 66%, and intention-to-treat analysis in 83%. Only one trial reported a loss to follow up greater than 15% – and that was only 16%. No study blinded participants or therapists, due to the inherent difficulties associated with these interventions.

Participants: The mean age of participants across studies ranged from 57 to 73 and they were on average within the first month after their stroke. Non-ambulatory was defined as Functional Ambulatory Category < 3 (five studies) and Motor Assessment Scale Item 5 score < 2 (one study).

Intervention: Mechanically assisted walking included treadmill with harness (two studies), treadmill with robotic device and harness (Lokomat) (one study) and electromechanical gait trainer with harness (three studies). The experimental group received some assisted overground walking as well as mechanically assisted walking in the majority of studies (four studies). The control group in all studies received overground walking assisted by therapists. Participants trained from 20 to 80 min/day, from 3 to 5 days/wk for 4 to 6 wk or until discharge from inpatient rehabilitation. The experimental group received the same amount of walking training as the control group in all studies.

Outcome measures: Independent walking was identified as the ability to walk 15 m continuously with no aids and in bare feet (one study), a Functional Ambulatory Scale score ≥ 3 (two studies) or > 3 (three studies). Independent walking data were available for six studies at 4 weeks and three studies at 6 months. Walking speed was measured during the 10-m Walk Test (three studies) and the 5-m Walk Test (two studies) and all results were converted to m/s. Walking speed data were available for five studies at 4 weeks and three studies at 6 months. Walking capacity was measured using the 6-min Walk Test (two studies) and the 2-min Walk Test (one study) and these results were multiplied to equate to 6 min. Walking capacity data were available for two studies at 4 weeks and at 6 months.

Effect of intervention

Independent walking: The short-term effect of mechanically assisted walking on independent walking was examined by pooling data at 4 weeks from six studies (Ada et al 2010, Du et al 2006, Ng et al 2008, Pohl et al 2007, Schwartz et al 2009, Tong et al 2006) involving 539 participants. Mechanically assisted walking increased independent walking compared with overground walking

---

Titles and abstracts screened (n = 2425)

→ Papers excluded after screening titles/abstracts (n = 2384)

↓

Potentially relevant papers retrieved for evaluation of full text (n = 43)
• from electronic search (n = 41)
• from registry search (n = 2)

→ Papers excluded after evaluation of full text (n = 36)*
• research design not RCT or Q-RCT (n = 17)
• PEDro Scale score ≤ 4 (n = 3)
• not subacute (n = 3)
• ambulatory participants included (n = 7)
• experimental intervention not mechanically assisted walking (n = 3)
• control did not include overground walking (n = 6)
• independent walking not an outcome measure (n = 8)
• same data reported in other study (n = 1)
• not enough information (n = 2)
• independent walking not an outcome (n = 8)

↓

Papers included in systematic review (n = 7)
Studies included in systematic review (n = 6)

Figure 1. Flow of studies through the review. * = papers may have been excluded for failing to meet more than one inclusion criterion, RCT = randomised clinical trial, Q-RCT = quasi-randomised clinical trial.

outcomes (ie, walking speed and capacity) were reported as the weighted mean difference (95% CI).

Results

Flow of studies through the review

The search returned 2425 papers. After screening the titles and abstracts, 41 papers were retrieved for evaluation of full text. Another two papers were retrieved as a result of searching trial registries. Thirty-six papers failed to meet the inclusion criteria and therefore seven papers (Ada et al 2010, Dean et al 2010, Ng et al 2008, Pohl et al 2007,

Table 2. PEDro scores for included studies (n = 6).

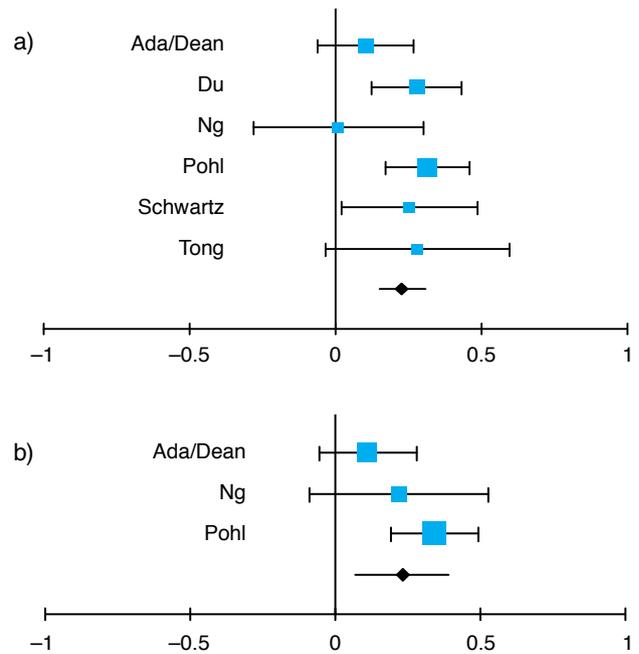| Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	<15% dropouts	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
Ada et al (2010) Dean et al (2010)	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Du et al (2006)	Y	N	Y	N	N	N	Y	N	Y	Y	5
Ng et al (2008)	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Pohl et al (2007)	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Schwartz et al (2009)	Y	N	Y	N	N	Y	N	Y	Y	Y	6
Tong et al (2006)	Y	N	Y	N	N	Y	Y	Y	Y	Y	7

Figure 2. Risk difference (95% CI) of effect of mechanically assisted walking for independent walking by pooling data from a) six studies at 4 weeks (n = 539) and b) three studies at 6 months (n = 312).

(RD = 0.23; 95% CI 0.15 to 0.30) (Figure 2a, see also Figure 3a on eAddenda for detailed forest plot), with 55% of participants in the experimental group being able to walk against 32% of participants in the control group.

The long-term effect of mechanically assisted walking on independent walking was examined by pooling data at 6 months from three studies (Ada et al 2010, Ng et al 2008, Pohl et al 2007), involving 312 participants. Mechanically assisted walking increased independent walking compared with overground walking (RD = 0.24, 95% CI 0.13 to 0.34), with 70% of participants in the experimental group being able to walk against 46% of participants in the control group. There was, however, between-study heterogeneity for this outcome at 6 months (I^2 = 51%), indicating that the variation between the results of the studies is above that expected by chance. When a random-effects model was applied the results were similar (RD = 0.23, 95% CI 0.07 to 0.39) (Figure 2b, see also Figure 3b on eAddenda for detailed forest plot).
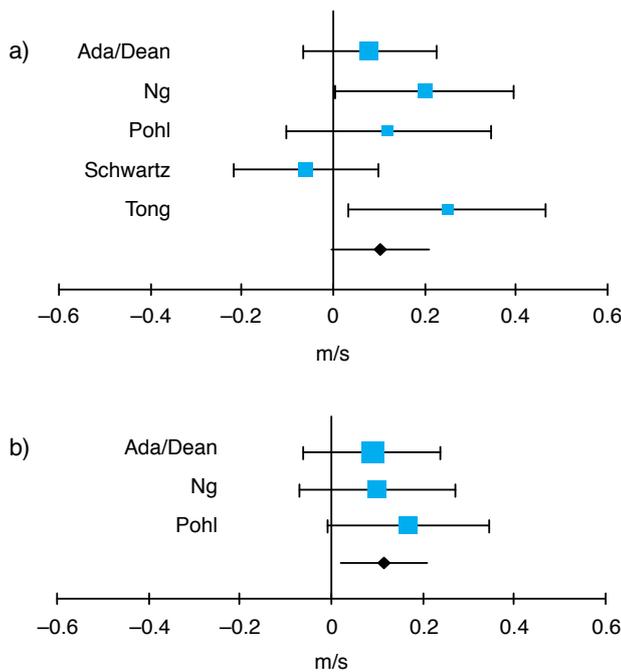
Walking speed: The short-term effect of mechanically assisted walking on walking speed was examined by pooling data from five studies (Dean et al 2010, Ng et al 2008, Pohl et al 2007, Schwartz et al 2009, Tong et al 2006), involving the 142 participants who could walk independently at 4 weeks. Mechanically assisted walking increased walking speed by 0.09 m/s (95% CI 0.01 to 0.17) more than overground walking. There was, however, between-study heterogeneity for this outcome at 6 months (I^2 = 41%), indicating that the variation between the results of the studies is above that expected by chance. When a random-effects model was applied the results were similar (MD = 0.10 m/s, 95% CI 0.00 to 0.21) (Figure 4a, see also Figure 5a on eAddenda for detailed forest plot).

The long-term effect of mechanically assisted walking on walking speed was examined by pooling data from

Table 3. Summary of included studies (n = 7).

Study	Design	Participants	Walking intervention	Walking outcome measures
Ada et al (2010) Dean et al (2010)	RCT	n = 126 Age (yr) = 73 (SD 12) Time since stroke (wk) = 2.4 Non-ambulatory = MAS < 2	Exp = treadmill with harness + assisted overground walking Frequency = 30 min x 5/wk until discharge Con = assisted overground walking Frequency = 30 min x 5/wk until discharge	Ability to walk independently = 15 m, no aid Speed = 10-m Walk Test (comfortable, no aids) Capacity = 6-min Walk Test Follow-up = 1/wk until discharge, 26 wk
Du et al (2006)	RCT	n = 128 Age (yr) = 57 (SD 6) Time since stroke (wk) = ≤ 12 Non-ambulatory = FAC < 3	Exp = treadmill with harness + assisted overground walking Frequency = 40 min x 2/day x 4 wk Con = assisted overground walking Frequency = 40 min x 2/day x 4 wk	Ability to walk independently = FAC ≥ 3 Speed = not measured Capacity = not measured Follow-up = 0, 4 wk
Ng et al (2008)	RCT	n = 38 Age (yr) = 70 (SD 11) Time since stroke (wk) = 2.6 Non-ambulatory = FAC < 3	Exp = electromechanical gait trainer with harness Frequency = 20 min x 5/wk x 4 wk Con = assisted overground walking Frequency = 20 min x 5/wk x 4 wk	Ability to walk independently = FAC > 3 Speed = 5-m Walk Test (fast, aids) Capacity = not measured Follow-up = 0, 4, 26 wk
Pohl et al (2007)	RCT	n = 155 Age (yr) = 63 (SD 12) Time since stroke (wk) = 4.4 Non-ambulatory = FAC < 3	Exp = electromechanical gait trainer with harness + assisted overground walking Frequency = gait trainer 20 min x 5/wk x 4 wk + assisted overground walking 25 min x 5/wk x 4 wk Con = assisted overground walking Frequency = 45 min x 5/wk x 4 wk	Ability to walk independently = FAC > 3 Speed = 10-m Walk Test (fast) Capacity = 6-min Walk Test Follow-up = 0, 4, 24 wk
Schwartz et al (2009)	RCT	n = 67 Age (yr) = 64 (SD 8) Time since stroke (wk) = 3.2 Non-ambulatory = FAC < 3	Exp = treadmill with robotic device and harness (Lokomat) + assisted overground walking Frequency = treadmill 30 min x 3/wk x 6 wk + assisted overground walking 30 min x 5/wk x 6 wk Con = assisted overground walking Frequency = 60 min x 3/wk + 30 min x 2/wk x 6 wk	Ability to walk independently = FAC ≥ 3 Speed = 10-m Walk Test (fast, aids) Capacity = 2-min Walk Test Follow-up = 0, 6 wk
Tong et al (2006)	RCT	n = 35 Age (yr) = 69 (SD 12) Time since stroke (wk) = 2.7 Non-ambulatory = FAC < 3	Exp = electromechanical gait trainer with harness Frequency = gait trainer 20 min x 5/wk x 4 wk Con = assisted overground walking Frequency = 20 min x 5/wk x 4 wk	Ability to walk independently = FAC > 3 Speed = 5-m Walk Test (fast, aids) Capacity = not measured Follow-up = 0, 4 wk

Exp = experimental group, Con = control group, BWS = Body Weight Support, FAC = Functional Ambulation Category, MAS = Motor Assessment Scale

Figure 4. Mean difference (95% CI) for effect of mechanically assisted walking on walking speed by pooling data from a) five studies at 4 weeks (n = 142) and b) three studies at 6 months (n = 172).
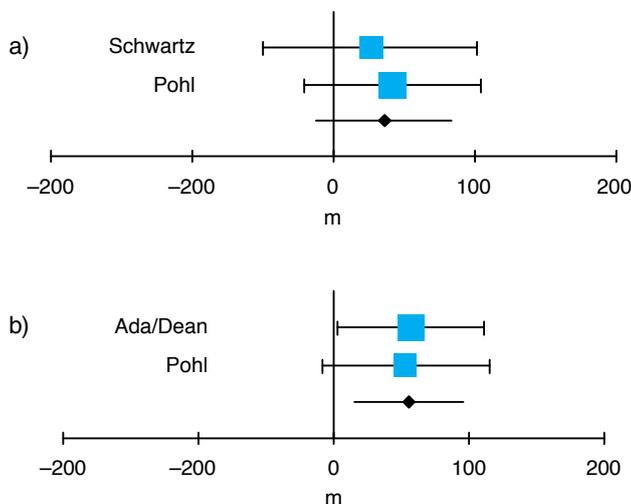
Figure 6. Mean difference (95% CI) of effect of mechanically assisted walking for walking capacity by pooling data from a) two studies at 4 weeks (n = 88) and b) two studies at 6 months (n = 152).

three studies (Ada et al 2010, Ng et al 2008, Pohl et al 2007), involving the 172 participants who could walk independently at 6 months. Mechanically assisted walking increased walking speed by 0.12 m/s (95% CI 0.02 to 0.21) more than overground walking (Figure 4b, see also Figure 5b on eAddenda for detailed forest plot).

Walking capacity: The short-term effect of mechanically assisted walking on walking capacity was examined by pooling data from two studies (Schwartz et al 2009, Pohl et al 2007), involving the 88 participants who could walk

independently at 4 weeks. Mechanically assisted walking increased walking capacity by 35 m (95% CI –13 to 84) more than overground walking (Figure 6a, see also Figure 7a on eAddenda for detailed forest plot).

The long-term effect of mechanically assisted walking on walking capacity was examined by pooling data from two studies (Ada et al 2010, Pohl et al 2007), involving the 152 participants who could walk independently at 6 months. Mechanically assisted walking increased walking capacity by 55 m (95% CI 15 to 96) more than overground walking (Figure 6b, see also Figure 7b on eAddenda for detailed forest plot).

Discussion

The strength of this systematic review is that it has pooled data from randomised trials of mechanically assisted walking (and included both treadmill and electro-mechanical gait trainers) with body weight support compared with the usual practice of overground walking in non-ambulatory people during the subacute phase of stroke. It includes six studies of reasonable size that have investigated the effect of mechanically assisted walking with body weight support on independence, speed and capacity of walking. The review provides evidence that mechanically assisted walking with body weight support increases the amount of independent walking without being detrimental to walking speed or capacity after 4 weeks of intervention. Furthermore, the benefits appear to be maintained at 6 months with walking speed and capacity being superior in patients who received mechanically assisted walking during inpatient rehabilitation.

The six studies included in this review were of moderate to good methodological quality. Given that 8 was the likely maximum PEDro score achievable (because it is not usually possible to blind the therapist or the participants), the mean score of 6.7 suggest that the findings are credible. There were sufficient data for a meta-analysis to be performed on each outcome measure. The number of participants included in the meta-analyses of independent walking was 539 at 4 weeks and 312 at 6 months. Even the meta-analyses of walking speed and capacity, which were carried out only on those who could walk, included numbers ranging from 88 to 172.

Meta-analysis indicated that, on average, 23% more patients (ie, 55% of participants in the experimental group compared with 32% of participants in the control group) could walk after 4 weeks of mechanically assisted walking with body weight support than could walk after assisted overground walking, ie, it decreased dependence for those patients who were non-ambulatory a few weeks after stroke. In addition, there were sufficient data from two trials to examine whether this benefit was maintained. At 6 months, there were still 24% more people (ie, 70% of participants in an experimental group compared with 46% of participants in a control group) walking having received mechanically assisted walking as an inpatient compared with those having received overground walking. Even though there was statistical heterogeneity between these studies suggesting caution, it is encouraging that the mean benefit was almost the same when a random effects model was applied (23% more patients walking) and was also the same as it had been at 4 weeks when 539 participants were pooled over six studies.

One hypothesis for the increase in independent walking with mechanically assisted walking is that this intervention provides the opportunity to complete more whole task walking practice than would be possible with overground walking alone. The allowable amount of time spent on walking was the same for the control group as the experimental group in all the studies. However, three studies report more distance covered or steps taken by the group receiving mechanically assisted walking than the group receiving assisted overground walking. Ada et al (2010) report that in Week 1 the average distance walked per session by the control group was only 20% of the experimental group and in the last week the distance was still less than 50%. Similarly, Pohl et al (2007) report that the average steps taken per session by the control group was less than 20% of the experimental group, and Tong et al (2006) report that the steps taken per session by the control group were 10% of the experimental group. Therefore, for a similar therapy time, more walking was carried out. Given the evidence from a systematic review of randomised trials that outcome after stroke is associated with the amount of practice undertaken (Kwakkel et al 2004), the extra walking carried out during the same therapy time probably explains why more patients receiving mechanically assisted walking walked independently than those receiving assisted overground walking.

Meta-analysis revealed that mechanically assisted walking resulted in more walking without compromising the walking itself. For those participants who could walk independently at 4 weeks, mechanically assisted walking with body weight support tended to produce 0.09 m/s higher walking speeds. The upper limit of the 95% CI only just spans a worthwhile effect which has been suggested as 0.16 m/s by Tilson et al (2010). However, it does strongly suggest that mechanically assisted walking is not detrimental to walking speed. Furthermore, at 6 months, there was a statistically significant improvement in walking speed of 0.12 m/s for participants who gained the ability to walk independently as a result of mechanically assisted walking and body weight support compared with overground walking. Furthermore, the upper limit of the 95% CI spans a worthwhile effect.

For those participants who could walk independently at 4 weeks, mechanically assisted walking with body weight support tended to produce 35 m further walking distance, with the average capacity achieved by participants in the experimental group being 144 m compared with 110 m achieved by participants in a control group. This strongly suggests that mechanically assisted walking is not detrimental to walking capacity. Furthermore, at 6 months, there was a statistically significant improvement in walking distance of 55 m for participants who gained the ability to walk independently as a result of mechanised walking and body weight support compared with overground walking. In the two studies that included a 6 month follow-up, the average distance walked in 6 min for the experimental group was 203 m compared with 148 m in the control group.

Our review reports similar findings to that of a recent Cochrane systematic review investigating the use of electromechanical gait trainers to improve walking after stroke. Mehrholz et al (2010) found that electromechanical gait training increased the odds of becoming independent in walking (OR 2.21, 95% CI 1.52 to 3.22) without detriment to walking speed (MD 0.04 m/s, 95% CI –0.05 to 0.14) or walking capacity (MD 7 m, 95% CI –32 to 46). Taken together, these reviews suggest that it is worthwhile to use some form of mechanical assistance to improve walking after stroke.

This review has some potential limitations. First, as is usual with studies of complex interventions, the outcome measures were not the same, although they were similar. Second, only half the studies measured the outcomes in the long term. Finally, most systematic reviews are susceptible to publication bias and we attempted to pre-empt this by including studies published in languages other than English.

In conclusion, this systematic review provides evidence that mechanically assisted walking results in more independent walking after 4 weeks of intervention in patients who cannot walk within the first month after stroke. Importantly, this increase is without detriment to walking speed or capacity. Further, benefits appear to be maintained at 6 months, with walking capacity and speed being superior in those who received mechanically assisted walking during inpatient rehabilitation. ∎

Correspondence: Assoc Prof Louise Ada, Discipline of Physiotherapy, Faculty of Health Sciences, The University of Sydney, Australia. Email: louise.ada@sydney.edu.au

References

Ada L, Dean CM, Morris ME, Simpson JM, Katrak P (2010) Randomised trial of treadmill walking with body weight support to establish walking in subacute stroke: the MOBILISE trial. *Stroke* 41: 1237–1242.

Baker B, Breen JC, Snyder D, Kelley T (2006) Body weight support treadmill training in community rehabilitation program improves walking in severely disabled stroke. *Journal of Neurologic Physical Therapy* 30: 210–210.

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 Reserach Methodology* 13: 50.

Bax L, Ikeda N, Fukui N, Yaju Y, Tsuruta H, Moons SGM (2008) More than numbers: the power of graphs in meta-analysis. *American Journal of Epidemiology* 169: 249–255.

Bogey R, Hornby GT (2007) Gait training strategies utilized in poststroke rehabilitation: are we really making a difference? *Topics in Stroke Rehabilitation* 14: 1–8.

Chen G, Patten C (2006) Treadmill training with harness support: selection of parameters for individuals with post stroke hemiparesis. *Journal of Rehabilitation Research & Development* 43: 485–497.

da Cunha Jr IT, Lim PA, Qureshy H, Henson H, Monga T, Protas EJ (2002) Gait outcomes after acute stroke rehabilitation with supported treadmill ambulation training: a randomized controlled pilot study. *Archives of Physical Medicine and Rehabilitation* 83: 1258–1265.

Davies PM (1999) Weight-supported treadmill training. *Neurorehabilitation and Neural Repair* 13: 167–169.

Dean CM, Ada L, Bampton J, Morris ME, Katrak P, Potts S (2010) Treadmill walking with body weight support in

subacute non-ambulatory stroke improves walking capacity more than overground walking: a randomised trial. *Journal of Physiotherapy* 56: 97–103.

Dean CM, Mackey FH (1992) Motor assessment scale scores as a measure of rehabilitation outcome following stroke. *Australian Journal of Physiotherapy* 38: 31–35.

Du JB, Song WQ, Wang MB (2006) The application of partial body weight support treadmill training in hemiplegia rehabilitation after stroke. *China Journal of Cerebrovascular Diseases* 3: 361–364.

Eng JJ, Tang PF (2007) Gait training strategies to optimize walking ability in people with stroke: A synthesis of the evidence. *Expert Review of Neurotherapeutics* 7: 1417–1436.

Guyatt GH, Pugsley SO, Sullivan MJ, Thompson PJ, Berman L, Jones NL (1984) Effect of encouragement on walking test performance. *Thorax* 39: 818–822.

Hakgüder A (2007) Bodyweight supported treadmill training in stroke rehabilitation. *Turkiye Fiziksel Tip ve Rehabilitasyon Dergisi* 53: 41–44.

Hesse S (1998) Treadmill training with partial body weight support for the restoration of gait of hemiparetic subjects. *Neurologie und Rehabilitation* 4: 113–118.

Hesse S, Eich HJ, Mach H, Parchmann H, Werner C (2005) Aerobic treadmill training plus physiotherapy improves walking speed and capacity in subacute moderately affected patients after stroke. *Neurologie und Rehabilitation* 11: 7–12.

Hesse S, Schmidt H, Werner C (2006) Machines to support motor rehabilitation after stroke: 10 years of experience in Berlin. *Journal of Rehabilitation Research & Development* 43: 671–678.

Hesse S (2006b) Gait training after stroke: a critical reprisal. *Annales de Réadaptation et de Médecine Physique* 49: 621–624.

Hesse S, Werner C, Schmidt H, Bardeleben A (2006c) Automated motor rehabilitation after stroke. *Nervenheilkunde* 25: 137–141.

Hesse S (2008) Treadmill training with partial body weight support after stroke: A review. *NeuroRehabilitation* 23: 55–65.

Hidler J, Nichols D, Pelliccio M, Brady K, Campbell DD, Kahn JH, et al (2009) Multicenter randomized clinical trial evaluating the effectiveness of the Lokomat in subacute stroke. *Neurorehabilitation and Neural Repair* 23: 5–13.

Holden MK, Gill KM, Magliozzi MR, Nathan J, Peihl–Baker L (1984) Clinical gait assessment in the neurologically impaired: reliability and meaningfulness. *Physical Therapy* 6: 35–40.

Hornby TG, Campbell DD, Kahn JH, Demott T, Moore JL, Roth HR (2008) Enhanced gait-related improvements after therapist- versus robotic-assisted locomotor training in subjects with chronic stroke: a randomized controlled study. *Stroke* 39: 1786–1792.

Husemann B, Muller F, Krewer C, Heller S, Koenig E (2007) Effects of locomotion training with assistance of a robot-driven gait orthosis in hemiparetic patients after stroke: a randomized controlled pilot study. *Stroke* 38: 349–354.

Ivey FM, Hafer-Macko CE, Macko RF (2008) Task-oriented treadmill exercise training in chronic hemiparetic stroke. *Journal of Rehabilitation Research and Development* 45: 249–259.

Keith RA, Granger CV, Hamilton BB, Sherwin FF (1987) The functional independence measure: a new tool for rehabilitation. In: Eisenberg MG, Grzesiak RC (Eds) Advances in Clinical Rehabilitation. New York: Springer Verlag, pp. 6–18.

Kosak MC, Reding MJ (2000) Comparison of partial body weight-supported treadmill gait training versus aggressive bracing assisted walking post stroke. *Neurorehabilitation and Neural Repair* 14: 13–19.

Kwakkel G, van Peppen R, Wagenaar R, Dauphinee SW, Richards C, Ashburn A, et al (2004) Effects of augmented exercise therapy time after stroke: a meta-analysis. *Stroke* 35: 2529–2536.

Langhammer B, Stanghelle JK, Lindmark B (2009) An evaluation of two different exercise regimes during the first year following stroke: a randomised controlled trial. *Physiotherapy Theory and Practice* 25: 55–68.

Langhorne P, Coupar F, Pollock A (2009) Motor recovery after stroke: a systematic review. *The Lancet Neurology* 8: 741–754.

Liang SQ, Peng XS, Yang JH (2005) Two-stage rehabilitative training in the recovery of walking ability in stroke patients with hemiplegia. *Chinese Journal of Clinical Rehabilitation* 9: 8–9.

Lord S, McPherson KM, McNaughton HK, Rochester L, Weatherall M (2008) How feasible is the attainment of community ambulation after stroke? A pilot randomized controlled trial to evaluate community-based physiotherapy in subacute stroke. *Clinical Rehabilitation* 22: 215–225.

Marincek C, Bajd T (2007) Surface FES-assisted walking. *Critical Reviews in Physical Rehabilitation Medicine* 19: 275–294.

Mayr A, Kofler M, Quirbach E, Matzak H, Fröhlich K, Saltuari L (2007) Prospective, blinded, randomized crossover study of gait rehabilitation in stroke patients using the Lokomat gait orthosis. *Neurorehabilitation and Neural Repair* 21: 307–314.

McCain KJ, Pollo FE, Baum BS, Coleman SC, Baker S, Smith PS (2008) Locomotor treadmill training with partial body-weight support before overground gait in adults with acute stroke: a pilot study. *Archives of Physical Medicine Rehabilitation* 89: 684–691.

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

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.

Ng MFW, Tong RKY, Li LSW (2008) A pilot study of randomized clinical controlled trial of gait training in subacute stroke patients with partial body-weight support electromechanical gait trainer and functional electrical stimulation: Six-month follow-up. *Stroke* 39: 154–160.

Nilsson L, Carlsson J, Danielsson A, Fugl-Meyer A, Hellström K, Kristensen L, et al (2001) 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. *Clinical Rehabilitation* 15: 515–527.

Peurala SH, Tarkka IM, Pitkänen K, Sivenius J (2005) The effectiveness of body weight–supported gait training and floor walking in patients with chronic stroke. *Archives of Physical Medicine and Rehabilitation* 86: 1557–1564.

Peurala SH, Airaksinen O, Jäkälä P, Tarkka IM, Sivenius J (2007) Effects of intensive gait–oriented physiotherapy during early acute phase of stroke. *Journal of Rehabilitation Research and Development* 44: 637–648.

Peurala SH, Airaksinen O, Huuskonen P, Jäkälä P, Juhakoski M, Sandell K, et al (2009) Effects of intensive therapy using gait trainer or floor walking exercises early after stroke. *Journal of Rehabilitation Medicine* 41: 166–173.

Pohl M, Werner C, Holzgraefe M, Kroczek G, Wingerdorf I, Hoölig G, et al (2007) Repetitive locomotor training and physiotherapy improve walking and basic activities of daily living after stroke: a single-blind, randomised multicentre trial (DEutsche GAngtrainerStudie, DEGAS). *Clinical Rehabilitation* 21: 17–27.

Richards CL, Malouin F, Wood-Dauphinee S, Williams JI, Bouchard JP, Brunet D (1993) Task-specific physical therapy for optimization of gait recovery in acute stroke patients.

Archives of Physical Medicine and Rehabilitation 74: 612–620.

Scheidtmann K, Brunner H, Muller F, Weinandy-Trapp M, Wulf D, Koenig E (1999) Treadmill training in early stroke patients – do timing and walking ability matter? *Neurorehabilitation and Neural Repair* 5:198–202.

Schmidt H, Werner C, Bernhardt R, Hesse S, Krüger J (2007) Gait rehabilitation machines based on programmable footplates. *Journal of NeuroEngineering and Rehabilitation* 4: 2.

Schwartz I, Sajin A, Fisher I, Neeb M, Shochina M, Katz-Leurer M, et al (2009) The effectiveness of locomotor therapy using robotic-assisted gait training in subacute stroke patients: a randomized controlled trial. *Physical Medicine and Rehabilitation* 1: 516–523.

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

Tong RK, Ng MF, Li LS (2006) Effectiveness of gait training using an electromechanical gait trainer, with and without functional electric stimulation, in subacute stroke: a randomized controlled trial. *Archives of Physical Medicine and Rehabilitation* 87: 1298–1304.

Tong RKY, Ng MFW, Li LSW, So EFM (2006b) Gait training of patients after stroke using an electromechanical gait trainer combined with simultaneous functional electrical stimulation. *Physical Therapy* 86: 1282–1294.

van de Port IGL, Wood-Dauphinee S, Lindeman E, Kwakkel G (2007) Effects of exercise training programs on walking competency after stroke: a systematic review. *American Journal of Physical Medicine and Rehabilitation* 86: 935–951.

Wade DT, Wood VA, Heller A, Maggs J, Langton Hewer R (1987) Walking after stroke. Measurement and recovery over the first 3 months. *Scandinavian Journal of Rehabilitation Medicine* 19: 25–30.

Werner C, Pohl M, Holzgraefe M, Kroczek G, Mehrholz J, Wingendorf I, Hölig G, et al (2006) Locomotor training in subacute stroke patients: results of a multicenter study (DEGAS). *Neurologie & Rehabilitation* 12: 262–269.

Wilson DJ (2007) Principles of gait rehabilitation and the efficacy of partial body-weight-supported training. *Critical Reviews in Physical Rehabilitation Medicine* 19: 169–194.