A novel weight-bearing strengthening program during rehabilitation of older people is feasible and improves standing up more than a non-weight-bearing strengthening program: a randomised trial

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Question: What is the feasibility and effectiveness of a novel weight-bearing strengthening program compared with that of a traditional non-weight-bearing strengthening program for older inpatients undergoing rehabilitation? **Design**: Randomised, controlled trial with concealed allocation, assessor blinding, and intention-to-treat analysis. **Participants**: Eighty-eight inpatients (11% loss to follow-up) aged on average 82 years old from three rehabilitation units with no contraindications to exercise. **Intervention**: Both the weight-bearing and non-weight-bearing strengthening programs were supervised by physiotherapists and were of similar intensities (10 to 15 RM) for two weeks. **Outcome measures:** The primary outcomes were standing up performance measured as minimum chair height, and strength measured as maximum isometric knee extensor force of both legs. The secondary outcomes were other mobility measures such as standing-up rate, walking, standing and overall mobility, and other strength measures such as maximum isometric hip extensor, hip abductor, and knee flexor force of both legs. **Results**: After the two-week intervention, the weight-bearing strengthening group had decreased their minimum chair height by 5.3 cm (95% CI 0.7 to 9.8) and increased their hip extensor strength on the weaker leg by 9 N (95% CI 1 to 17) more than the non-weight-bearing strengthening group. There were no clinically-worthwhile or statistically-significant differences between the groups for any other measures. **Conclusion**: This novel weight-bearing strengthening program was feasible and safe in an inpatient rehabilitation setting and had some additional benefits over a traditional non-weight-bearing strengthening program. **[Olivetti L, Schurr K, Sherrington C, Wallbank G, Pamphlett P, Kwan M M-S, Herbert RD (2007) A novel weight-bearing strengthening program during rehabilitation of older people is feasible and improves standing up more than a non-weight-bearing strengthening program: a randomised trial. *Australian Journal of Physiotherapy* 53: 147–153]**

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Introduction

Lower limb weakness increases with advancing age (Ostchega et al 2004) and is associated with disability (Rantanen et al 1999), reduced gait speed (Ostchega et al 2004), and falls in older people (Moreland et al 2004). Following periods of hospitalisation, older people often experience increased levels of disability (Gill et al 2004) and high falls rates (Mahoney et al 1994). This is likely to be due to a combination of the presenting condition (eg, stroke) and a loss of strength associated with periods of relative immobility.

There is now strong evidence that progressive resistance training can increase older people's muscle strength. However, effects on mobility are less clear (Latham et al 2003). Research in this area has been conducted largely in community settings, but there is also evidence that residents of aged care facilities can make significant gains in strength and mobility with progressive resistance training (Fiatarone et al 1994).

There is increasing evidence of the role of rehabilitation in enhancing mobility particularly for people after stroke (Wade and de Jong 2000). Older people may benefit from a period of intensive inpatient rehabilitation to enhance physical abilities prior to discharge from hospital. Few authors have investigated the role of high intensity strength training in inpatient settings but some have reported that strength training is feasible in inpatient settings (Sullivan 2001, Mitchell 2001).

The most effective strategy for strength training is yet to be established. Strengthening programs commonly target individual muscles in isolation without reference to the context in which that muscle is required to function. For example, knee extensor muscles are commonly strengthened in a non-weight-bearing position, where the foot is free to move, using weights (Latham et al 2003) or machines (Fiatarone et al 1994) for resistance. (This is sometimes called open-chain exercise.) However, for most daily tasks such as standing up from a chair, walking and stair climbing, the foot is in contact with the ground and the muscles work to control the body over the foot. A number of studies have examined strengthening of the extensor muscles of the leg by bearing weight through the foot and extending the leg against resistance provided by the person's body weight (Nugent et al 1994, Sherrington et al 2003).

Several authors have now investigated the effects of adding additional resistance to these weight-bearing (closed-chain) exercises (ie, weight-bearing strength training). This has been done with weighted waist belts (Rooks et al 1997, Lindelof et al 2002), weighted vests (Alexander et al 2001, Jessup et al 2003, Bean et al 2004), hand weights (Barrett and Smerdely 2002), or elastic tubing (Bunout et al 2005).

It has been argued that weight-bearing strength training is likely to be more effective than non-weight-bearing strength training (Rutherford 1988, Carr and Shepherd 2003). This argument is based on the observation that training produces increases in strength that are specific to the muscle action used in training (Morrissey et al 1995), possibly because of the importance of the neural component of strength adaptations (Sale 1988). This would indicate that it may be more effective to strengthen muscles in the skill in which they need to be strong such as standing-up, walking and stair climbing. The fact that many studies of strength training in older people are conducted in non-weight-bearing or open chain conditions may help explain the inconsistent effects of strength training on mobility (Latham et al 2003).

We (Sherrington 2003, 2004) and others (Krebs 2007) have found additional benefits from exercises performed in weight-bearing positions compared to non-weight-bearing exercises, but to date no studies have directly compared non-weight-bearing and weight-bearing *strengthening* programs among older people. We therefore developed a novel weight-bearing strengthening program for use in an inpatient rehabilitation setting. The purpose of this study was to test the feasibility and effectiveness of such a program. The research questions were:

1. Does 2 weeks of a novel weight-bearing strengthening program enable older people undergoing inpatient rehabilitation to stand up from a lower chair and result in stronger knee extensors than a traditional non-weight-bearing strengthening program?

2. Does it also result in any other mobility gains or stronger lower limb muscles?

Method

Design

An assessor-blinded, randomised controlled trial was conducted. The rehabilitation unit physiotherapist treating each potential participant determined eligibility, obtained informed consent, and conducted the initial assessment. After the initial assessment, participants were randomly assigned to a weight-bearing or non-weight-bearing strengthening group using a concealed allocation procedure (numbered sealed opaque envelopes). The allocation schedule was generated with a random number table. The physiotherapist then commenced training following the allocated exercise protocol. Final assessments were performed by an independent physiotherapist who was blind to treatment group allocation. These physiotherapists did not work within the rehabilitation unit and particular care was taken to ensure that they did not see the interventions occurring. Detailed measurement protocols were developed and all assessors were trained in the measurement procedures. Ethical approval was granted by the South Western Sydney and South Eastern Sydney Area Health Service Research Ethics Committees.

Participants

Older people admitted to the inpatient rehabilitation wards at three hospitals in Sydney, Australia, were recruited for this study. Participants were included if they were over the age of 60, unable to stand up from a 35-cm stool without using their hands, able to give informed written consent and follow instructions necessary to complete the program, and able to actively extend the knee and abduct the hip. Potential participants were excluded if they would have been unable to complete the assessment or carry out either exercise program due to cognitive impairment or medical conditions that prevented bearing weight on one or both lower limbs, had severe cardiac dysfunction or fragile skin that prevented participation in the program, or where the cause of weakness was progressive in nature (eg, multiple sclerosis or motor neuron disease).

Intervention

Participants in both groups were prescribed up to four different strengthening exercises from a standard set, according to their individual abilities. Exercises for both groups were designed to enhance muscle strength according to the principle of progressive resistance training. The target exercise intensity for participants in both groups was a 10 to 15 repetition maximum (RM) load (ie, the load that participants could lift 10 to 15 times before fatigue). Three sets of each exercise were conducted at this intensity. In both groups the load was progressed as participants' strength increased to maintain the 10 to 15 RM. Both legs were trained in each participant.

The weight-bearing strengthening group exercised with some weight borne through the foot and leg. The exercises included: lateral step-ups to a block placed under the training foot in a semi-reclined position on a tilting table and/or in standing (Nugent et al 1994), standing up and sitting down, and stepping up onto a step. If participants were unable to do these exercises they practised bearing weight through the leg in sitting and lying.

Exercises for the non-weight-bearing strengthening group consisted of pulley exercises for four different lower limb muscle groups (knee extensors, knee flexors, hip extensors, hip abductors) in a seated or lying position with no weight borne through the foot or leg. Protocols for the execution of these exercises were developed from discussion with various Australian physiotherapy departments to reflect closely what is considered current practice in physiotherapy (see eAddenda for full details of the trial method).

Participants in both groups received training with feedback about the exercises being performed. Training volumes and loads were recorded in a training log and variations from the protocol were noted. Participants practised walking and other mobility tasks (such as stair climbing) consistent with their rehabilitation goals. Rehabilitation unit physiotherapists were asked to offer equal volumes and intensities of usual task practice to both groups. Participants' physical activity on the wards was not restricted or logged. All other therapies (eg, occupational therapy, speech and language therapy) continued regardless of participation in the study.

Training was conducted by a ward physiotherapist in an inpatient rehabilitation gymnasium. The aim was to complete five sessions per week over a two-week period. This period was chosen as it could feasibly be conducted within the current length of stay in the rehabilitation wards. Contamination between groups was minimised by training participants in different groups at different times where possible.

Table 1. Characteristics of participants.

Characteristic	WBSG n = 43	NWBSG n = 45
Age *(yr)*, mean (SD)	82.4 (5.5)	81.0 (6.7)
Sex, n female (%)	22 (51)	25 (56)
Primary diagnosis, n (%)		
Fall	7 (16)	7 (16)
Decreased mobility	7 (16)	6 (13)
General surgical procedure	2 (7)	6 (13)
Acute illness	8 (19)	11 (24)
Fracture/orthopaedic surgery	7 (16)	5 (11)
Stroke	12 (28)	8 (18)
Other neurological condition	0 (0)	2 (4)
Other conditions, n (%)		
Neurological	21 (49)	18 (40)
Cardiac	24 (56)	31 (69)
Respiratory	14 (31)	12 (27)
Arthritis	23 (54)	26 (58)
Two or more co-morbidities, n (%)	38 (88)	36 (80)

WBSG = weight-bearing strengthening group, NWBSG = non-weight-bearing strengthening group

Outcome measures

We measured both impairment (strength) and activity performance (mobility). The primary outcomes were standing up performance measured as minimum chair height, and strength measured as maximum isometric knee extensor force of both legs. For minimum chair height, participants sat on an adjustable electrical plinth with their feet placed under their knees and arms folded to constrain the use of the upper limbs. Floor markers were placed at the position of the feet. Participants were not allowed to move the elbows away from the body or move their feet or push on the plinth with the back of their legs. The minimum height from which they could stand up under these constraints was measured using a tape measure mounted on a ruler. This procedure has acceptable inter-rater reliability (Schurr et al 2002). For each participant, a normalised measure of the minimum chair height was obtained by multiplying the participant's minimum chair height by the average shank length of all participants of the same gender as the participant, and dividing by the participant's shank length. Minimum chair height data could not be obtained from some participants because they could not stand from any height. These participants were assigned the mean minimum chair height plus three standard deviations, a value which approximated the worst performance.

Isometric knee extension strength was measured using a 'make test' with a hand-held dynamometer positioned at the level of the malleoli with participants sitting with hips and knees at 90 deg flexion. The strength measure was taken after one practice contraction. The best of three attempts was recorded. On the basis of these measures the 'stronger' and 'weaker' leg was determined. As a number of participants had unilateral problems (such as stroke) all strength data were analysed for the stronger and weaker leg separately.

The secondary outcomes were other mobility measures such as standing up rate, walking, standing and overall mobility, as well as other strength measures such as maximum isometric hip extensor, hip abductor, and knee flexor force of both legs. Strength was measured after one practice contraction using a hand-held dynamometer ('make test') with participants in sitting (for knee flexors) and supine (for hip extensors and hip abductors). The best of three attempts was recorded.

Standing up rate, standing, and overall mobility were measured with the Physical Performance and Mobility Examination (Winograd et al 1994). Participants performed physical tasks of bed mobility, transferring from bed to chair, standing up from a 45-cm chair multiple times, standing balance with feet in different positions (feet apart, together, semi-tandem and tandem), walking six metres, and stepping up onto a small step, and were assisted as required. Scoring was on a 3-level scale (2 = high pass, 1 = low pass, 0 = fail) giving a maximum score of 12. The time taken to stand up five times was recorded and converted to a rate (number/s). Participants who were unable to stand up were assigned a value of zero. The total time the person was able to balance in tandem standing and semi-tandem standing was recorded in seconds.

For walking, participants were asked to walk six metres as quickly as possible with no physical assistance using the least supportive walking aid as judged safe by the assessor. Marker pens were attached to participants' heels with tape, making marks on the floor as they walked (Cerny 1983). The number of steps and average step length and width were determined from the marks. Time taken to walk six metres was recorded with a stopwatch and converted to a velocity.

Data analysis

Power calculations *a priori* indicated that 88 participants would be sufficient to detect between-group differences in the primary outcomes of 20 percent (power ≥ 0.8, p = 0.05).

Continuous data were analysed with linear regression models and dichotomous data (walking aid used) were analysed using logistic regression models. Each model assessed the effects of group allocation at Week 2. To increase precision of estimates, Week 0 values were entered into the regression models as the only covariates. All available data were analysed by initial group assignment (ie, an intention-to-treat approach). The extent of improvement (from Week 0 to Week 2) for all participants (ie, both groups combined) was assessed using paired t-tests.

Results

Flow of participants through the trial

Participant characteristics are summarised in Table 1. There were no clinically important differences between the two study groups at the initial assessment. The average age of participants was 82 years (SD 6, range 67 to 96) and 53 percent were women. The primary diagnosis for 30 percent of participants was a generalised mobility limitation or fall, and for 25 percent of the sample it was a stroke or other neurological condition. The remaining participants were undergoing a rehabilitation program after a recent acute illness or a general surgical or orthopaedic procedure. Forty-five percent of participants had two or more other conditions.

Ten participants did not undertake the final measures, giving a loss to follow-up of 11 percent. Six of these withdrew consent (four in the non-weight-bearing strengthening group and two in the weight-bearing strengthening group) and four (three from the non-weight-bearing strengthening

Table 2. Mean (SD) groups, mean (SD) difference within groups, and mean (95% CI) difference between groups for all outcomes.

Outcome	Groups				Difference within groups		Difference between groups*
	Week 0		Week 2		Week 2 minus Week 0		Week 2 minus Week 0
	WBSG n = 40	NWBSG n = 38	WBSG n = 37	NWBSG n = 35	WBSG	NWBSG	WBSG minus NWBSG
Strength *(N)*							
Knee extensor–stronger leg	125 (54)	116 (45)	122 (45)	111 (47)	–5 (44)	0 (39)	2 (–15 to 18)
Knee extensor–weaker leg	100 (44)	92 (38)	109 (34)	97 (46)	6 (37)	7 (41)	5 (–11 to 21)
Knee flexor–stronger leg	75 (32)	65 (29)	75 (32)	73 (29)	0 (22)	9 (26)	–6 (–16 to 4)
Knee flexor–weaker leg	61 (30)	56 (30)	64 (24)	65 (28)	2 (22)	8 (30)	–4 (–13 to 6)
Hip extensor–stronger leg	74 (31)	75 (27)	82 (31)	76 (26)	9 (23)	5 (20)	5 (–4 to 14)
Hip extensor–weaker leg	64 (30)	66 (22)	76 (28)	68 (25)	13 (20)	4 (18)	9 (1 to 17)
Hip abductor–stronger leg	43 (21)	41 (15)	44 (19)	48 (19)	1 (17)	7 (20)	–5 (–12 to 2)
Hip abductor–weaker leg	40 (22)	36 (15)	40 (20)	42 (18)	2 (17)	5 (18)	–3 (–10 to 5)
Mobility							
Standing up minimum chair height *(cm)*	60.4 (17.3)	60.0 (12.6)	50.5 (8.9)	55.7 (13.9)	–10.5 (15.2)	–5.2 (11.4)	–5.3 (–9.8 to –0.7)
Standing up rate *(number/s)*, median (IQR)	0.10 (0.21)	0.12 (0.11)	0.13 (0.13)	0.19 (0.20)	0.03 (0.16)	0.08 (0.17)	–0.05 (–0.13 to 0.02)
Tandem stance time *(s)*, median (IQR)	0.0 (1.0)	0.0 (2.0)	1.0 (10.0)	0.0 (5.2)	2.6 (4.2)	1.3 (3.6)	1.3 (–0.5 to 3.0)
Semi-tandem stance time *(s)*, median (IQR)	1.4 (8)	3 (10)	10 (8)	10 (10)	3.6 (5.2)	1.7 (4.3)	1.8 (–0.4 to 4.0)
Physical Performance and Mobility Examination *(0 to 12)*	6.4 (2.5)	6.5 (2.5)	8.1 (2.3)	7.5 (2.6)	1.7 (2.3)	1.0 (0.8)	0.7 (–0.2 to 1.5)
Walking velocity *(m/s)*, median (IQR)	0.36 (0.36)	0.26 (0.40)	0.41 (0.52)	0.37 (0.54)	0.14 (0.25)	0.14 (0.30)	0.00 (–0.13 to 0.13)
Walking step length *(cm)*	26.6 (12.6)	24.2 (12.5)	31.9 (14.3)	28.8 (13.9)	7.1 (10.8)	4.5 (10.9)	2.9 (–2.1 to 7.9)
Walking step width *(cm)*	11.0 (4.2)	11.7 (5.4)	11.9 (4.3)	12.2 (4.4)	1.4 (4.6)	0.1 (5.3)	0.8 (–1.1 to 2.6)

WBSG = weight-bearing strengthening group, NWBSG = non-weight-bearing strengthening group, * = between-group differences derived from ANCOVA of Week 2 score with Week 0 score as covariate, shaded rows = primary outcomes

group and one from the weight-bearing strengthening group) were too unwell for reasons unrelated to the exercise program. At Week 2, the minimal chair height measure was not performed on six additional subjects (three from each group) due to participant fatigue or refusal.

Compliance with trial method

Full exercise logs were available for 71 participants. These showed that the weight-bearing strengthening group did an average of 1110 exercise repetitions (SD 504, range 40 to 2045) in an average 7.5 sessions (SD 2.1, range 2 to 10) over the two-week period. For the non-weight-bearing strengthening group the average total number of repetitions was similar (mean 981, SD 634, range 0 to 2621) in an average of 6.8 sessions (SD 2.6, range 0 to 10). The median number of different exercises completed by both groups was four (weight-bearing strengthening group range 2 to 4, non-weight-bearing strengthening group range 0 to 4).

Participants in both groups reported experiencing similar levels of difficulty carrying out the exercises. Sixty-one percent of the non-weight-bearing strengthening group and 55 percent of weight-bearing strengthening group found the exercises difficult or very difficult. Participants in both groups had similar perceptions of how much they had improved during the intervention phase. Fifty-eight percent of the non-weight-bearing strengthening group and 68 percent of the weight-bearing strengthening group reported feeling moderately or markedly stronger. Sixty-nine percent of the non-weight-bearing strengthening group and 65 percent of the weight-bearing strengthening group reported that they felt their walking was greatly or moderately

Table 4. Mean (95% CI) extent of improvement for all participants together for all outcomes.

Outcome	Week 2 minus Week 0
Strength *(N)*	
Knee extensor–stronger leg	–3 (–12 to 7)
Knee extensor–weaker leg	6 (–3 to 15)
Knee flexor–stronger leg	4 (–1 to 10)
Knee flexor–weaker leg	5 (–1 to 11)
Hip extensor–stronger leg	7 (2 to 12)
Hip extensor–weaker leg	8 (4 to 13)
Hip abductor–stronger leg	4 (–1 to 8)
Hip abductor–weaker leg	3 (–1 to 7)
Mobility	
Standing up minimum chair height *(cm)*	–7.9 (–11.2 to –4.7)
Standing up rate *(number/s)*	0.06 (0.02 to 0.09)
Tandem stance time *(s)*	2.0 (1.1 to 2.9)
Semi-tandem stance time *(s)*	2.7 (1.6 to 3.8)
Physical Performance and Mobility Examination *(0 to 12)*	1.35 (0.88 to 1.82)
Walking velocity *(m/s)*	0.14 (0.08 to 0.20)
Walking step length (cm)	5.8 (3.2 to 8.4)
Walking step width *(cm)*	0.72 (–0.50 to 1.95)

shaded rows = primary outcomes

better. Seventy-seven percent of the non-weight-bearing strengthening group and 76 percent of the weight-bearing strengthening group said they would definitely or probably continue the exercises. There were no major adverse events that could be attributed to the exercise program.

Effect of intervention

Group data for the two measurement occasions as well as within- and between-group data are presented in Table 2, while individual data for the two measurement occasions are presented in Table 3 (see eAddenda). The weight-bearing strengthening group had decreased their minimum chair height by 5.3 cm (95% CI 0.7 to 9.8, $p = 0.03$) and increased their hip extensor strength on the weaker leg by 9 N (95% CI 1 to 17 $p = 0.04$) more than the non-weight-bearing strengthening group. There were no clinically-worthwhile or statistically-significant differences between the groups for any other measures. At the beginning of the trial, 23 participants (53%) in the weight-bearing strengthening group and 16 participants (36%) in the non-weight-bearing strengthening group could walk unaided or with one stick. By Week 2, these numbers were 28 (67%) and 22 (52%) (OR = 0.74, 95% CI 0.25 to 2.19, $p = 0.59$). When missing Week 2 values for the minimum chair height test were replaced with Week 0 values (six participants), the direction and size of the between group difference was similar to the initial analysis (4.8 cm, 95% CI 0.4 to 9.3, $p = 0.04$).

When all participants were considered together, hip extensor strength increased by 7 N (95% CI 2 to 12, $p = 0.01$) on the stronger leg and by 8 N (95% CI 4 to 13, $p < 0.001$) on the weaker leg from Week 0 to Week 2. Standing up minimum chair height decreased by 8 cm (95% CI 11 to 5, $p < 0.001$), standing up rate increased by 0.06/s (95% CI 0.02 to 0.09, $p = 0.003$), tandem standing time increased by 2.0 s (95% CI 1.1 to 2.9, $p < 0.001$), semi-tandem standing time increased by 2.7 s (95% CI 1.6 to 3.8, $p < 0.001$), Physical Performance and Mobility Examination improved by 1.4 points (95% CI 0.9 to 1.8, $p < 0.001$), walking velocity increased by 0.14 m/s (95% CI 0.08 to 0.20, $p < 0.001$), and average step length increased by 5.8 cm (95% CI 3.2 to 8.4, $p < 0.001$), from Week 0 to Week 2 (Table 4).

Discussion

This study establishes that strength training is feasible for frail elderly patients in a 'real-world' inpatient rehabilitation setting. This supports previous findings of smaller studies (Sullivan 2001, Mitchell 2001). Interventions were given as part of usual care by hospital physiotherapists. There were no adverse events from either intervention, which suggests that the exclusion criteria effectively minimised the risk these interventions pose for this population. The sample was fairly heterogeneous which enhances the applicability to rehabilitation settings with similarly heterogeneous populations.

The novel weight-bearing strengthening program led to greater improvements in two of the outcome measures and comparable levels of improvement in others. After the two-week intervention, participants in the weight-bearing strengthening group were able to stand up, without using the upper limbs to assist, from a chair that was 5 cm lower than the non-weight-bearing strengthening group. In our opinion, the size of this effect is clinically worthwhile. Given that standing up is a critical task for independent living, a between-group difference of this size warrants the use of the novel resistance training intervention. This finding builds on previous findings that greater improvements in activity performance are possible when exercises are carried out in weight-bearing positions (Sherrington 2003, 2004, Krebs 2007) and that weight-bearing strength training is feasible (Rooks et al 1997, Lindelof et al 2002, Alexander et al 2001, Jessup et al 2003, Bean et al 2004), but is the first to directly compare weight-bearing and non-weight-bearing strength training.

The clinical importance of the between-group difference in the hip extension muscle strength is less clear. Nonetheless the average 9 N benefit of weight-bearing strength training compared to non-weight-bearing strength training was more than 10 percent of baseline values and thus may have implications for activity performance.

The 2-week duration of the intervention is a limitation of the study. The decision to test a 14-day program was based on likely length of stay at our inpatient rehabilitation unit. Despite the short duration, we chose to focus on strength training given the likely importance of muscle weakness in this population. While longer programs would be required to induce muscle hypertrophy, we postulated that it would be possible to detect differences between the two programs within two weeks due to the neural component of muscle strength adaptations (Sale 1988). It may be that greater between-group differences would be seen from a longer duration program.

The physiotherapists who delivered the intervention programs reported that the weight-bearing strength training was easier to implement than the traditional strengthening program, particularly for people with fragile skin (as there are no cuffs or weights attached to the limb), people with arthritis or compromised joints, and those with difficulty moving around on a bed or lying supine (due, eg, to cardiac and respiratory problems). Non weight-bearing strengthening may be more suitable for people who are difficult to assist while standing (eg, large people who are unsteady).

Participants in both weight-bearing and non-weight-bearing strengthening groups improved on most measures. Participants also underwent task-related training and a range of other interventions as part of the usual care in the rehabilitation unit. Natural recovery and learning effects on test measures may have contributed to these improvements. The absence of a group who did not receive strength training is a limitation of the design and means that it is not possible to differentiate any common contribution of the weight-bearing and non-weight-bearing strengthening programs to these improvements. Further research could attempt to tease out the relative benefits of different components of inpatient rehabilitation programs.

In conclusion, the novel weight-bearing strengthening program was feasible and safe in an inpatient rehabilitation setting and had some additional benefits over a traditional non-weight-bearing strengthening program.

eAddenda: Trial method and Table 3 available at www.physiotherapy.asn.au/AJP

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Statement regarding registration of clinical trials from the Editorial Board of *Australian Journal of Physiotherapy*

This journal is moving towards requiring that clinical trials whose results are submitted for publication in *Australian Journal of Physiotherapy* are registered. From January 2008, all clinical trials submitted to the journal must have been registered prospectively in a publicly-accessible trials register. We will accept any register that satisfies the International Committee of Medical Journal Editors requirements. Authors must provide the name and address of the register and the trial registration number on submission.