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# Mobility training after hip fracture: a randomised controlled trial

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## Abstract

**Objective:** to compare the effects of two different exercise programmes after hip fracture.
**Design:** assessor-blinded randomised controlled trial.
**Setting:** hospital rehabilitation units, with continued intervention at home.
**Subjects:** 160 people with surgical fixation for hip fracture transferred to inpatient rehabilitation.
**Method:** in addition to other rehabilitation strategies, the intervention group received a higher dose (60 min/day) exercise programme conducted whilst standing and the control group received a lower dose exercise programme (30 min/day) primarily conducted whilst seated/supine. The primary outcome measures were knee extensor muscle strength in the fractured leg and walking speed, measured at 4 and 16 weeks.
**Results:** 150 participants (94% of those recruited) completed the trial. There were no differences between the groups for the two primary outcome measures. *Post hoc* analyses revealed increased walking speed among those in the higher dose, weight-bearing exercise group with cognitive impairment at 4 and 16 weeks.
**Conclusions:** there was no benefit (or harm) due to the higher dose, weight-bearing exercise programme with respect to the primary outcome measures. However, people with hip fracture and cognitive impairment gained greater benefit from the higher dose programme than from the lower dose programme.

Keywords: *hip fracture, mobilisation, physical therapy, rehabilitation, cognitive impairment, elderly*

## Introduction

Hip fractures are an important public health issue as outcome after hip fracture is often poor [1]. Current best practice in hip fracture management involves little delay to surgical repair and subsequent mobilisation [2]. However, the optimal type and intensity of mobilisation remain unclear. The Cochrane review focusing on mobilisation strategies after hip fracture included 13 trials but concluded that there was insufficient evidence to determine the relative effectiveness of different strategies [3]. It does seem that higher dose interventions after hip fracture are associated with larger effects on physical functioning [4, 5].

Among younger people, exercise most relevant to the task trained leads to the greatest improvements in performance in that task (e.g. [6]). We found that, among people after hip fracture, an exercise programme conducted whilst standing resulted in reduced need for gait aids in inpatient rehabilitation [7] and greater improvements in balance and functional abilities in community dwellers [8] when compared to an exercise programme conducted whilst seated or supine. There is evidence from the stroke literature that a higher dose of exercise leads to greater improvements in physical functioning [9], and that exercise which involves weight-bearing functional task practice [10] and treadmill walking with some body weight support [11] can be particularly effective. We drew on these pieces of evidence to develop a 'best-practice' exercise programme for people after hip fracture which involved a higher dose of exercise with an emphasis on exercises conducted whilst standing (i.e. weight bearing).

We conducted a randomised controlled trial to determine whether, in addition to usual rehabilitation care, a higher dose exercise programme conducted whilst standing led to greater improvements in mobility after hip fracture than a more traditional programme of bed and chair exercises conducted at a lower dose. The experimental hypothesis was that the *higher dose weight-bearing exercise* programme would produce better mobility, strength and balance (with no additional complications) than the *lower dose limited weight-bearing exercise* programme.

## Method

### Participants

Participants were recruited from the inpatient rehabilitation units of three teaching hospitals in Sydney, Australia, between March 2002 and May 2005. These patients represent a middle band of people with hip fracture. High functioning patients who are discharged directly to home and low functioning patients who are discharged to a residential aged care facility from the acute orthopaedic ward were excluded.

All people with surgical fixation for hip fracture admitted to the inpatient rehabilitation units who fulfilled the following criteria were invited to participate: approval to weight bear or partial weight bear; able to tolerate the exercise programmes; able to take four plus steps with a forearm support frame and the assistance of one person; no medical contraindications that would limit ability to exercise; living at home or low care residential facility prior to the hip fracture, with the plan to return to this accommodation at discharge. Subjects with cognitive impairment were included if a carer who was able to supervise the exercise programme was available. If no carer was available, subjects with $>4$ adjusted errors on the Short Portable Mental Status Questionnaire were excluded [12]. Subjects provided informed consent to participate. The study complied with the Declaration of Helsinki and was approved by the relevant institutional ethics committees.

Participants were randomly allocated to either the higher dose weight-bearing exercise (HIGH) group or the lower dose limited weight-bearing exercise (LOW) group. Randomisation was stratified for recruitment site and pre-fracture Barthel Index (i.e. $\geq 80/100$ or $<80/100$) [13]. The allocation sequence was generated from computer software and concealed using consecutively numbered, sealed and opaque envelopes.

### Interventions

Participants in the HIGH group undertook weight-bearing exercise twice daily for a total of 60 min per day for 16 weeks. Five weight-bearing exercises were prescribed in addition to walking on a treadmill with partial body weight support using a harness (for inpatients) or a walking programme (after hospital discharge). The five weight-bearing exercises used for both legs included stepping in different directions, standing up and sitting down, tapping the foot and stepping onto and off a block. Hand support could be used if necessary. The exercises were progressed by reducing support from the hands, increasing block height, decreasing chair height and increasing the number of repetitions. This commenced as an inpatient programme, followed by home visits and a structured home exercise programme after inpatient discharge. The home exercise programme incorporated the five weight-bearing exercises used in the inpatient phase, plus a walking programme. The frequency of home visits gradually decreased.

Participants in the LOW group undertook five exercises in sitting or lying plus a small amount of walking using parallel bars or walking aids for a total of 30 min each day for 4 weeks. The exercises were progressed by increasing the repetitions and resistance. This type of exercise programme is commonly prescribed after hip fracture and represents usual care [14]. This commenced as an inpatient programme, followed by weekly home visits and a structured home exercise programme incorporating the same exercises. After 4 weeks participants were provided with a tailored programme of limited weight-bearing exercises and encouraged to continue exercising; no further physiotherapy home visits were undertaken.

All participants received usual post-operative mobilisation (e.g. walking practice in the ward), and the rehabilitation programme usually provided by other health professionals (e.g. occupational therapists) and any gait aids were progressed as per usual protocols. No other physiotherapy treatments were administered during the trial.

### Outcomes

Outcomes were assessed at baseline, 4 weeks and 16 weeks. All measurements were made by assessors who were blinded to group allocation. The two primary outcomes were knee extensor strength in the fractured leg and walking speed. Isometric knee extensor strength at 90° was measured in the fractured leg using a spring balance. This test has good test–retest reliability in people with hip fracture [intraclass correlation coefficient (ICC) 0.85] [15], and muscle weakness is a risk factor for falls [16]. Walking speed was measured over a 6 m distance using a stop watch. This is reliable among people following hip fracture (ICC 0.97) [15] and is valid [17].

Secondary outcomes included functional abilities, balance abilities, pain, fear of falling, quality of life, length of stay in hospital, residential status and community service utilisation after discharge, adverse events and adherence with the treatment programmes. Functional abilities were measured using the Physical Performance and Mobility Examination [18], sit-to-stand time (i.e. the time to sit-to-stand-to-sit five times from a 45 cm seat height) [8], gait aid use and the Barthel Index [13]. Balance was assessed using a battery of six standardised tests [19–23]. Participants were also asked to rate their current mobility, strength and balance on five-point Likert scales. Pain was measured using a seven-item ordinal scale. The Modified Falls Efficacy Scale was used to quantify fear of falling [24]. Quality of life was assessed using the EQ 5D and expressed as a utility score [25].

Falls and hospital readmissions were obtained using a falls calendar collected at the 4 and 16 week assessments and via a postal survey at 10 weeks. Participants were asked if treatment had any negative effects and, if so, the nature of the effects. Participants completed exercise diaries which were analysed to ascertain adherence to the programmes.

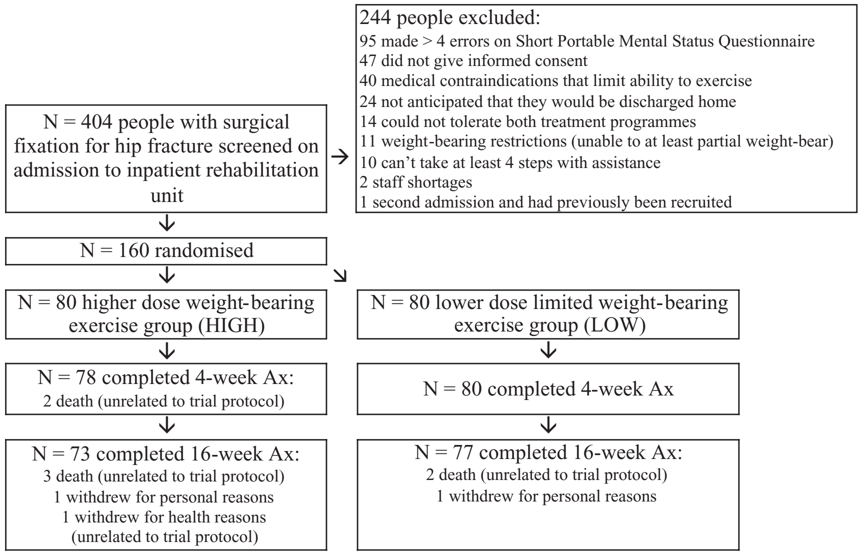


Figure 1. Recruitment and flow of participants.

### Sample size

We estimated that a sample of 160 subjects (80 in each group) would provide an 80% probability of detecting differences between group means of 0.1 m/s in walking speed (SD = 0.2 m/s) and 25 N in quadriceps strength (SD = 50 N) [8]. We assumed a correlation of 0.6 between pre- and post-test scores, an alpha of 0.05, a loss to follow-up of 10% and 20% non-compliance.

### Statistical analyses

All analyses were by intention to treat. To test the effects of treatment, between-group differences were examined with analysis of covariance using a linear regression approach. Separate analyses were performed on 4 and 16 week follow-up data. The primary time point was 4 weeks. Pre-test scores were entered into the model as covariates. When distributions were highly skewed, change scores were compared using linear regressions. Categorical data were dichotomised and between-group differences were compared using logistic regression models.

Three *post hoc* sub-group analyses were performed based on three predictors of outcome after hip fracture—pre-fracture disability, surgical procedure used and pre-existing cognitive impairment. Participants with a pre-fracture Barthel Index of ≤95 were classified as having pre-fracture disability [26], surgical procedure was dichotomised to pin and plate or arthroplasty and participants with ≥3 adjusted errors on the Short Portable Mental Status Questionnaire were classified as cognitively impaired [12]. The effects of the combination of group allocation and sub-group status were quantified using interaction terms in linear and logistic regression models.

## Results

### Participants

The participant flow is in Figure 1. One hundred and sixty people were randomised, 158 (99%) completed the 4 week assessment and 150 (94%) the 16 week assessment. Participant characteristics are listed in Table 1. There were no clinically important differences between the groups.

### Compliance with the trial protocol

During the inpatient phase, total exercise time with a physiotherapist or physiotherapy assistant was significantly greater for the HIGH group than for the LOW group [median (IQR) HIGH = 543 (463) min, LOW = 363 (318) min, $P = 0.001$]. Both groups spent a similar amount of time practicing overground walking and exercising, but the HIGH group completed additional treadmill walking. During the community phase, the HIGH group were visited by study physiotherapists a median of 8 times (IQR 4) and the LOW group were visited a median of 4 times (IQR 1). Exercise rates (days on which exercise was undertaken/days in study) were similar between groups, and the HIGH group reported walking for a median of 517 min (IQR 1,125).

People with cognitive impairment had a lower overall exercise rate than those without (between-group difference = −16%, 95% CI −24 to −8%, $P < 0.001$), but there was some indication that those with cognitive impairment had a greater exercise rate in the HIGH group (the effect of the interaction between group and cognitive status = 14%, 95% CI −2 to 31%, $P = 0.096$).

### Outcomes

Baseline, 4 and 16 week data for the HIGH and LOW groups are in Table A in the supplementary data file (available at *Age and Ageing* online). Both groups experienced substantial but incomplete recovery over the 16 week follow-up period.

There were no statistically significant or clinically relevant between-group differences at 4 weeks or 16 weeks for either walking speed or knee extensor strength (Table 2, columns 2 and 3; $P > 0.05$ for all between-group comparisons). With the exception of two secondary outcomes, differences between groups were small and not statistically significant (Table 2,

Table 1. Participant characteristics and primary outcome variables at baseline for the higher dose weight-bearing exercise (HIGH) group and the lower dose non-weight-bearing exercise (LOW) group

| | HIGH ($N = 80$) | LOW ($N = 80$) |
|---|---|---|
| Gender (male:female) | 15:65 | 15:65 |
| Mean (SD) age at injury (years) | 84 (8) | 84 (7) |
| Mean (SD) height (cm) | 160.5 (11.0) | 158.7 (9.3) |
| Mean (SD) mass (kg) | 61.7 (12.5) | 58.9 (13.6) |
| Type of pre-fracture accommodation | | |
| House:unit:flat at family home:independent living unit:hostel | 49:8:2:3:18 | 48:15:3:3:11 |
| Pre-fracture prescription medication use (excluding vitamins) | | |
| Takes ≥4 medications (yes:no) | 69:11 | 69:11 |
| Takes cardiovascular system medications (yes:no) | 74:6 | 69:11 |
| Takes musculoskeletal system medications (yes:no) | 8:72 | 11:69 |
| Takes psychoactive medications (yes:no) | 27:53 | 25:55 |
| Median (IQR) pre-fracture medical conditions | 4 (2–5) | 4 (3–5) |
| Median (IQR) community services used pre-fracture | 1 (0–2) | 0 (0–1) |
| Social support | | |
| Has someone to confide in (yes:no:missing) | 76:4:0 | 76:3:1 |
| Encouragement from confidant (discourages:neutral:encourages) | 1:21:54 | 0:22:54 |
| Walking aid used pre-fracture | | |
| None: crutches | 36:1 | 34:1 |
| 1 single-point stick:1 quadruped stick:2 single-point sticks | 22:1:1 | 30:2:2 |
| Pick up frame:rollator:forearm support frame | 4:13:2 | 2:8:1 |
| Pre-fracture disability, Barthel Index ≤95 (no:yes) | 50:30 | 44:36 |
| Median (IQR) falls in 12 months before hip fracture | 1 (1–2) | 1 (1–2) |
| Hip fractured (left:right) | 41:39 | 54:26 |
| Type of fracture | | |
| Intra-capsular, non-displaced (Garden I/II): missing | 14:2 | 14:0 |
| Intra-capsular, displaced (Garden III/IV) | 26 | 24 |
| Trochanteric, two-part:trochanteric, multi-part: sub-trochanteric | 19:17:2 | 18:22:2 |
| Type of surgery | | |
| Multiple bone screws:compression screw and plate:other | 3:42:1 | 5:45:0 |
| Hemiarthroplasty:bipolar hemiarthroplasty:total arthroplasty | 24:8:2 | 21:6:3 |
| Median (IQR) time from fracture to surgery (days) | 1 (1–3) | 1 (1–2) |
| Median (IQR) time from fracture to rehabilitation admission (days) | 14 (9–21) | 12 (9–19) |
| Mean (SD) post-fracture blood haemoglobin level (g/dl) | 11.2 (1.5) | 11.2 (1.2) |
| Mean (SD) post-fracture blood albumin level (g/dl) | 32.5 (4.7) | 32.8 (5.5) |
| Pressure ulcer on admission to rehabilitation unit (yes:no) | 7:73 | 9:71 |
| Urinary catheter on admission to rehabilitation unit (yes:no) | 3:77 | 4:76 |
| Cognitive impairment ≥3 adjusted errors on the Short Portable Mental Status Questionnaire (no:yes) | 50:30 | 56:24 |
| Mean (SD) knee extensor strength, fractured leg (kg) | 7.4 (3.3) | 6.8 (3.4) |
| Mean (SD) walking speed (m/s) | 0.30 (0.22) | 0.28 (0.16) |

columns 2 and 3). The HIGH group had significantly faster sit-to-stand times at both 4 and 16 weeks and completed more steps in the step test at 4 weeks compared to the LOW group. No adverse effects of the intervention were detected. Participants in the HIGH group had a total of 73 falls, and those in the LOW group had 77 falls.

*Post hoc* analyses were performed to explore whether subgroups of participants showed differences in response to the intervention. For a number of variables, there was a significant interaction between group allocation and cognitive impairment. Specifically, those with cognitive impairment who were allocated to the HIGH group had better outcomes than those without both of these factors at either or both of the post-intervention assessments as measured by walking speed, Physical Performance and Mobility Examination score, step test, maximal balance range, body sway, coordinated stability test, Barthel Index, EQ 5D, Modified Falls Efficacy Scale, walking aid use and pain (Table 2, columns 4 and 5). Those with arthroplasty allocated to the HIGH group had higher walking speed at 16 weeks, but no effects were detected for the secondary outcome variables (Table B in the supplementary data file, available at *Age and Ageing* online). Pre-fracture disability did not influence the results.

## Discussion

When conducted in addition to other rehabilitation interventions, there was no additional benefit of a higher dose weight-bearing exercise programme following hip fracture when compared with a lower dose programme that focused on exercises in sitting and supine. However, in the third of participants who had cognitive impairment there was a statistical and clinically relevant improvement in functioning as a result of the HIGH programme. No adverse effects of the higher dose programme were detected.

Table 2. Between-group differences (ANCOVA-adjusted mean difference and 95% confidence intervals) for the primary analysis (i.e. HIGH versus LOW) plus the *post hoc* analyses to test the interaction between group and impaired cognition

| | Between-group differences for all participants[a] | | Effect of both HIGH group & impaired cognition[a] | |
|---|---|---|---|---|
| | 4 Week | 16 Week | 4 Week | 16 Week |
| Knee extensor strength, fractured leg (kg) | −0.1 (−1.3–1.1), *0.853* | 0.6 (−0.8–2.1), *0.389* | 0.2 (−2.5–2.5), *0.991* | 1.8 (−1.2–4.9), *0.239* |
| Walking speed (m/s) | 0.03 (−0.03–0.10), *0.345* | 0.01 (−0.08–0.11), *0.793* | 0.20 (0.07–0.34), *0.003* | 0.24 (0.05–0.44), *0.015* |
| PPME | 0.3 (−0.2–0.9), *0.219* | 0.3 (−0.4–1.0), *0.433* | 1.4 (0.3–2.6), *0.013* | 1.9 (0.3–3.4), *0.019* |
| Sit-to-stand (number/s) | 0.06 (0.02–0.10), *0.002* | 0.04 (0.01–0.08), *0.026* | 0.00 (−0.08–0.08), *0.930* | 0.07 (−0.01–0.15), *0.098* |
| Barthel Index[b] | 3 (−2–8), *0.196* | 1 (−4–6), *0.771* | 18 (8–27), *0.000* | 17 (6–27), *0.002* |
| Max balance range test (mm) | 5 (−7–18), *0.378* | −7 (−21–7), *0.321* | 9 (−17–35), *0.512* | 36 (7–66), *0.016* |
| Step test (standing on affected leg) | 1.9 (0.3–3.4), *0.017* | 1.4 (−0.3–3.0), *0.100* | 0.2 (−3.1–3.4), *0.915* | 3.5 (0.07–6.8), *0.046* |
| Body sway, total path (cm)[b,c] | 3.3 (−3.7–1.4), *0.352* | −1.9 (−8.6–4.8), *0.577* | 2.1 (5.4–34.8), *0.008* | 9.8 (−4.3–23.8), *0.171* |
| Lateral stability, tandem (mm)[b,c] | 8 (0–16), *0.064* | 0 (−7–8), *0.949* | 13 (−5–30), *0.158* | 12 (−4–29), *0.129* |
| Coordinated stability test (errors)[b,c] | −3 (−7–2), *0.291* | −2 (−7–4), *0.592* | 6 (−4–17), *0.213* | 14 (2–26), *0.020* |
| Choice stepping reaction time (s)[b,c] | | 0.33 (−0.36–1.02), *0.340* | | 0.97 (−0.49–2.43), *0.190* |
| Modified Falls Efficacy Scale | 6 (−2–15), *0.145* | 6 (−4–16), *0.263* | 15 (−4–33), *0.115* | 28 (7–49), *0.009* |
| EQ 5D | 0.02 (−0.07–0.10), *0.712* | 0.01 (−0.09–0.09), *0.919* | 0.14 (−0.04–0.32), *0.114* | 0.20 (0.02–0.39), *0.034* |
| Length of inpatient rehabilitation (days) | | 3 (−1–8), *0.151* | | 3 (−7–13), *0.528* |
| Able to walk unaided or with sticks or crutches | 1.2 (0.6–2.6), *0.598* | 1.0 (0.5–1.9), *0.990* | 3.9 (0.3–44.5), *0.268* | 6.0 (1.4–26.7), *0.018* |
| Self-rated mobility as good | 1.0 (0.5–2.0), *0.981* | 1.6 (0.8–3.1), *0.157* | 2.1 (0.5–8.7), *0.302* | 2.4 (0.6–1.3), *0.225* |
| Self-rated strength as good | 1.7 (0.8–3.7), *0.175* | 1.5 (0.8–3.0), *0.217* | 3.0 (0.4–21.2), *0.267* | 0.9 (0.2–3.6), *0.844* |
| Self-rated balance as good | 0.7 (0.4–1.6), *0.429* | 0.7 (0.4–1.4), *0.363* | 1.8 (0.4–8.5), *0.486* | 1.5 (0.4–6.0), *0.596* |
| No or slight pain | 0.8 (0.4–1.6), *0.540* | 0.9 (0.5–1.7), *0.691* | 0.9 (0.2–3.4), *0.834* | 5.3 (1.3–22.1), *0.024* |
| Accommodation in the community | | 0.7 (0.4–1.4), *0.356* | | 1.7 (0.4–7.2), *0.453* |
| Uses no community services | | 2.2 (1.0–5.2), *0.064* | | 0.8 (0.1–5.1), *0.774* |
| Fell during the study | | 0.9 (0.4–1.8), *0.727* | | 0.2 (0.1–1.1), *0.074* |
| Readmitted to hospital during the study | | 0.8 (0.3–1.9), *0.566* | | 0.1 (0.0–1.2), *0.071* |
| Participant reported negative effects | 1.1 (0.6–2.1), *0.784* | 0.6 (0.3–1.3), *0.236* | 0.8 (0.2–3.4), *0.810* | 0.7 (0.1–3.8), *0.644* |

The primary outcomes are shaded in grey.
PPME = Physical Performance and Mobility Examination; [a]data are ANCOVA-adjusted mean (95% confidence interval), *P-value* or odds ratio (95% CI), *P-value*; [b]between-group differences were assessed using change from baseline; [c]a higher score reflects poorer performance; negative between-group differences indicate that the HIGH performs better than the LOW group.

There are four possible explanations for the similarity in results between the HIGH and LOW groups overall. First, treatment received by both groups represented a small proportion of the total rehabilitation and was insufficient to produce large effects. Second, treatment received by the LOW group may not have been sufficiently different to that received by the HIGH group. Third, therapists could not be blinded to group allocation, so the existing rehabilitation programme for participants in the LOW group may have been modified. Finally, it is possible that the HIGH programme does not provide additional benefits.

The benefit of the HIGH exercise seen in participants with cognitive impairment is consistent with the finding that intensive geriatric rehabilitation reduces the length of stay in people after hip fracture with mild and moderate dementia [27]. Participants with cognitive impairment may have responded to either the increased supervision or exercise specificity in the HIGH group. The provision of increased supervision may permit a more appropriate progression of the exercise programme or the completion of a greater quantity of exercise. Analysis of exercise diaries revealed that among participants with cognitive impairment, those in the HIGH group exercised on 15% more of the days in the study than those in the LOW group. It should be noted that participants with cognitive impairment were only recruited to our trial if they had a family carer who was available to supervise the exercise programme at home. The interaction between arthroplasty and improved walking speed for the HIGH group was unexpected and is probably a chance finding.

Our clinical trial was carefully designed and implemented according to a strict experimental protocol. The sample size was adequate, with a very low dropout rate and good compliance with the exercise programmes. Two weaknesses of the study are the possible insufficient difference between the HIGH and LOW exercise programmes and the relatively short (i.e. 16 weeks) duration of the exercise programmes. However, the programmes studied continued substantially longer than most rehabilitation currently available after hip fracture in Australia. It is also possible that the outcome measures used were insufficiently sensitive to the changes in function that occurred in the study.

Of the 13 clinical trials of exercise after hip fracture [3], the two trials with the largest effects have involved broad programmes involving balance, strength, endurance and functional task training which were more intensive and more highly supervised than our programme [4, 5]. It is our impression that a number of the participants in our study would not have tolerated a programme of this nature within the first few months after fracture. Further research is required to establish the optimum timing, type and intensity of exercise for enhanced mobility after hip fracture.

## Conclusion

There was no overall detectable benefit (or harm) due to the higher dose and weight-bearing exercise programme on the primary outcome measures. For people with hip fracture and cognitive impairment, the higher dose and weight-bearing exercise was more effective than lower dose and limited weight-bearing exercise for mobility, balance, activities of daily living and quality of life.

## Key points

- No overall benefit (or harm) was found from a higher dose programme of exercises whilst standing than from a lower dose supine/seated exercise programme in people receiving post-hip fracture rehabilitation.
- People with hip fracture and cognitive impairment gained greater benefit from the higher dose exercise programme.

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## Conflicts of interest

There are no conflicts of interest. This manuscript contains original material that has not been published and is not be under consideration by another journal. Preliminary results were presented as abstracts at the Australasian Faculty of Rehabilitation Medicine Annual Scientific Meeting (May 2006), and Australian Falls Prevention Conference (November 2006).

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## Supplementary data

Supplementary data mentioned in the text are available at *Age and Ageing* online.

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