# The effect of physical rehabilitation on activities of daily living in older residents of long-term care facilities: systematic review with meta-analysis


## Abstract

### Background

The worldwide population is ageing. One expected consequence of this is an increase in morbidity and an associated increased demand for long-term care. Physical rehabilitation is beneficial in older people but relatively little is known about effects in residents of long-term care facilities.

### Objective

To examine the effects of physical rehabilitation on activities of daily living (ADL) in elderly residents of long-term care facilities.

### Methods

Systematic review with meta-analysis of randomised controlled trials. We included studies that compared the effect of a physical rehabilitation intervention on independence in ADL with either no intervention or an alternative intervention in older people (over 60 years) living in long-term care facilities. We searched 19 databases including the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, CINAHL, AMED, Web of Knowledge and Google Scholar.

Two researchers independently screened papers and extracted data. Outcomes of included studies were combined in a standardised mean difference random-effects meta-analysis.

### Results

Thirteen of 14 studies identified were included in the meta-analysis. Independence in ADL was improved by 0.24 standard units (95% CI: 0.11 to 0.38; P=0.0005). This is equivalent to 1.3 points on

the Barthel Index (0-20 scale). No significant differences in effect were found based on participant or intervention characteristics. Larger sample size and low attrition were associated with smaller estimates of effect. All studies were assessed to be at risk of bias.

## Conclusions

Physical rehabilitation may improve independence for elderly long-term care facility residents but mean effects are small. It is unclear which interventions are most appropriate.

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## Background

Changes in life expectancy and birth rates mean that by 2050 the proportion of the world's population over 60 is expected to double from 11% to 22% [**1**] and the number of residents in long-term care facilities is expected to increase significantly [**2**]. Elderly long-term care facility residents are some of the frailest members of our community. Residents identify mobility as central to their well-being [**3**] and many cannot independently perform basic activities of daily living (ADL) [**4**]. It is reported that residents currently spend much of their time physically inactive and with little social interaction [**5**, 6]. Inactivity can lead to acute illnesses [**7**] and is associated with all-cause mortality [**8**, 9]. For their health and well-being, and to reduce costs of care, interventions to improve independence in ADL should be sought and evaluated.

Physical rehabilitation is defined here as an intervention intended to maintain or improve the physical health or function of people through their participation in physical action. Systematic reviews provide evidence that it is effective at improving certain physical outcomes in older long-term care populations [**10-13**]. However, the effect on ADL is ambiguous, with only one narrative review (27 studies) reporting firm evidence of a positive effect [**12**]. In the recently updated Cochrane review, we evaluated the effects of physical rehabilitation in older residents of long-term care facilities (67 studies; 6300 residents) on a range of outcomes including independence in ADL [**13**]. Several ADL outcome measures were reported and we summarised the results by calculating mean differences for each measure. However, this technique required separate meta-analyses for studies using the Barthel Index (7 studies; statistically significant improvement) and the Functional Independence Measure (4 studies; non-significant effect), and studies using other ADL measures were not included. Thus, the findings were difficult to interpret.

The systematic review reported here is based on the randomised controlled trials (RCTs) identified in the Cochrane review [**13**], but presents a new analysis using the standardised mean difference

approach to combine the ADL outcome measures and therefore provides an improved estimate for the pooled results. Reasons for differences in effect estimates are also explored.

## [See Appendix: Methods]

## Results

34,069 references were screened and 14 studies [**17-30**] described in 18 reports [**17-30**, 31-34] fulfilled the eligibility criteria and were included in this review (see figure 1).

[FIGURE 1 ABOUT HERE]

Eight of the studies were RCTs [**17-19**, **22**, **23**, **25**, **29**, **30**]; the remaining six were cluster RCTs [**20**, **21**, **24**, **26-28**].Three cluster trials used an analysis that accounted for clustering [**24**, **27**, **28**].

Seven of the studies were conducted in Europe, six in North America and one in Japan.

### Participants

The studies included 2379 participants (median = 126) with a mean (standard deviation (SD)) age of 84 (8) years; 79% were female. With regards to physical function, four studies limited participation to residents with some degree of dependence in ADL [**22**, **26-28**], while four required some minimum level of physical function to participate (e.g. standing, walking) [**17**, **18**, **25**, **30**].
At baseline, mean (SD) Barthel Index scores (0-20 scale) ranged from 10(5) [**28**] to 14(2) [**29**] in the seven studies that presented them.

Six studies presented mean Mini-Mental State Examination (MMSE) scores (0 to 30 scale, lower scores indicate greater cognitive impairment): one study had mean MMSE less than 10 [**30**], two studies had mean MMSE between 10 and 20 [**26**, **29**] and three studies had mean MMSE between 20 and 25 [**17**, **22**, **24**].

## Interventions

The 14 studies examined 15 rehabilitation interventions, with one study comparing two rehabilitation groups with a control group [**21**].The interventions were delivered for a median of four months, ranging between ten weeks [**17**] and twelve months [**24**].

Seven of the interventions were group exercise classes [**17-21**, **25**, **29**]. These all included some form of resistance training, five included mobility training [**18**, **19**, **21**, **25**, **29**], four included balance training [**17-19**, **25**], four included flexibility exercises [**18**, **19**, **25**, **29**] and two included ball games [**18**, **29**]. Five of these were delivered by rehabilitation professionals [**17**, **19**, **20**, **25**, **29**] while two were delivered by carers and volunteers [**18**, **21**]. Three were delivered with music [**20**, **25**, **29**]. These were all delivered twice [**20**, **25**] or three times weekly [**17-19**, **29**] except for Morris 1999 [**21**] where three resistance and three endurance sessions were delivered each week. Each session lasted between 45 and 75 minutes, although this was not reported for two studies [**19**, **21**].

Two further interventions were group-based [**26**, **30**]. One involved mobility exercises selected for the individual based on functional ability [**26**]. This was delivered individually when a participant did not attend the session. Sessions lasted 45 minutes and occurred five times every fortnight. The other involved practice of ADL in a group setting [**30**]. Sessions lasted 2½ hours and occurred five times a week.

Four interventions involved professional delivery of physiotherapy [**22**], occupational therapy [**28**] or both [**23**, **27**]. These involved individual sessions which were tailored based on assessments. The repertoire of available therapies included ADL practice and mobility training. Mulrow 1994 [**22**] also emphasised resistance and balance training to enable ADL practice. This intervention was delivered in 30-45 minute sessions, three-times weekly; the other three did not report typical frequency or duration of sessions. Two included training of care staff to promote independence [**27**, **28**].

Two interventions involved encouraging a resident to take a more active part in routine activities such as transferring, bathing or dressing themselves, delivered by nurses and assistants following assessment and goal-setting [**21**, **24**].

We judged the intensity of the interventions as high in seven cases [**17**, **18**, **21**, **22**, **25**, **26**, **29**], low in three [**19**, **20**, **30**] and unclear in five [**21**, **23**, **24**, **27**, **28**] (these were tailored to the participant).

### Comparison conditions

Nine studies compared their intervention with usual care. It was typically unclear what, if any, rehabilitation was provided as part of usual care. Three studies compared their rehabilitative intervention with a social intervention [**20**, **22**, **26**], one study had both a usual care control group and a social control group [**30**], while one compared a high intensity exercise intervention with a seated range of motion intervention [**18**].

## Outcome measures

The included studies reported five different measures of independence in ADL (details in table 1): Barthel Index [**17**, **20**, **24**, **26-29**], Functional Independence Measure (FIM) [**17-19**, **23**], Katz Index of Independence in ADL [**22**, **25**, **29**], Physical Self-Maintenance Scale [**30**] and a summary measure of eight items from the Minimum Data Set [**21**]. Two studies reported two of these scales: Dorner 2007 [**17**] measured both Barthel Index and FIM while Santana-Sosa 2008 [**29**] reported both Barthel Index and Katz ADL scale.

In all studies outcome measures were taken at the end of the intervention. Three studies reported additional follow-up, 3 months after the end of the intervention [**26-28**].

[TABLE 1 ABOUT HERE]

## Attrition

Missing outcome data ranged from 3% [**19**] to 45% [**22**]. In total, 469 allocated participants (21%) were not included in the final analysis.

## Risk of bias

Overall, no study had a low risk of bias across all the domains assessed. For selection bias, four studies were judged to be at low risk [**20**, **26-28**], nine studies had an unclear risk [**17-19**, **21**, **22**, **24**, **25**, **29**, **30**] and one study had a high risk [**23**]. For performance bias, the risk was judged unclear for five studies [**18**, **20-22**, **26**] and high for nine studies [**17**, **19**, **23-25**, **27-30**]. For detection bias, risk was judged as low for ten studies [**18**, **19**, **21**, **23-25**, **27-30**], unclear for two studies [**17**, **22**] and high for two studies [**20**, **26**]. Risk of attrition bias was judged as low for five studies [**22**, **24**, **25**, **27**, **28**], unclear for five studies [**17**, **19**, **26**, **29**, **30**] and high for four studies [**18**, **20**, **21**, **23**]. Risk of reporting bias was judged as unclear for twelve studies [**17-22**, **24-26**, **28-30**] and high for two studies [**23**, **27**]. No other risks of bias were identified. Because no study had a low risk of bias for blinding of participants and personnel or selective reporting, those studies with low risk of bias across all other domains were selected as a group (lower risk of bias, [**27**, **28**]) for comparison with the other studies (higher risk of bias).

## Effect of rehabilitation

### Data handling

Przybylski 1996 [**23**] did not present the numbers in each intervention group at follow-up, but did present total numbers, balanced numbers in each group at baseline and reported that attrition was similar. We therefore assumed equal drop-out in each group and similar numbers in each group at follow-up. For Santana-Sosa 2008 [**29**], values were derived from the presented graphs. Sackley 2009 [**27**] only presented an analysis adjusted for clustering at 3 months after the end of the intervention, therefore we used these values.

Two of the cluster trials reported ICCs of independence in ADL in long-term care institutions [**27**, **28**], from which a pooled ICC was calculated as 0.38. This was used to adjust the estimate of effect in trials that did not account for clustering in their analysis [**20**, **21**, **26**].

Santana-Sosa 2008 [**29**] has 16 participants in total and an effect estimate of 1.82, which is over twice the size of the second largest estimate (0.77, [**18**]). We therefore chose to exclude it from the main meta-analysis as an unreliable outlier that may represent publication bias (increased likelihood of small studies being published if they estimate large effects) or super-realisation bias (researchers managing delivery, attendance and other factors beyond what would occur in reality).

In order to convert the results of meta-analysis into a commonly used scale, we estimated the standard deviation of the Barthel Index (0-20 scale) in this population as 5.4, using baseline data from the two largest trials that reported the Barthel Index in this review [**24**, **27**].

## Estimated effect

On average, rehabilitation improved independence in ADL by 0.24 standard units (95% CI: 0.11 to 0.38; P = 0.0005) in comparison with control conditions (figure 2). This is equivalent to 1.3 points on the Barthel Index (0-20 scale). There was little between study heterogeneity ($I^2$ = 0%; $Chi^2$ = 12 on 12 degrees of freedom (df); P = 0.4).

[FIGURE 2 ABOUT HERE]

## Subgroup analyses

Results of subgroup analyses are reported in table 2. Subgroup analyses based on the age of the participant groups found no significant differences of effect. Subgroup analyses based on the duration, delivery mode and intensity of interventions found no significant differences in effect. There was evidence that studies with over 100 participants produced smaller estimates of effect than those with fewer (P = 0.005). There was some evidence that studies with less than 20% of participants lost to follow-up produced smaller estimates of effect than those with more (P = 0.05).

No significant effect was found in analyses based on risk of bias, use of a cluster trial design or the particular measure of ADL independence used.

[TABLE 2 ABOUT HERE]

The sensitivity analysis that included Santana-Sosa 2008 [**29**], estimated a larger effect size of 0.31 standard units and a wider confidence interval (95% CI: 0.14 to 0.48), equivalent to 1.7 points on the Barthel Index. It also introduced significant heterogeneity ($I^2$ = 29%; $Chi^2$ = 18 on 13df; P = 0.1).

Because of the apparent biases in effect estimates of smaller studies and those with high attrition, a post-hoc sensitivity analysis limited to studies with over 100 participants and less than 20% attrition was conducted as a conservative estimate of effect. Among the five studies meeting this criteria [**19**, **21**, **22**, **25**, **26**] the pooled effect estimate was 0.10 standard units (95% CI: -0.08 to 0.27; P = 0.27). This estimate is equivalent to a half point average increase in the Barthel Index (0-20 scale). There was very little statistical heterogeneity ($I^2$ = 0%; $Chi^2$ = 2 on 4df; P = 0.7).

## Discussion

This systematic review and meta-analysis provides evidence that physical rehabilitation is associated with improvement in ADL independence in elderly residents of long-term care facilities. In contrast with other reviews [**10-13**], we have calculated a single estimate of the size of effect on ADL. The size of this mean effect (0.24 standard units) is conventionally interpreted as small [39], and is slightly smaller than estimates of minimal clinically important difference for the Barthel Index in chronic stroke survivors (1.45 or 1.85 points, compared with 1.3 points estimated here) [40]. However, this is a different patient population and it could be argued that independence in ADL is so important that even small improvements may be worthwhile and meaningful. Additionally, the effects of rehabilitation appear variable, with individual participants likely to benefit to a greater or lesser extent than the estimate, and suggesting some interventions may have a medium effect while others may be ineffective. Nonetheless, bias may have affected the estimate and the true effect may be

smaller. It remains unclear which combinations of interventions and participants are associated with the greatest effect [**13**].

It is plausible that the small effect found is one of maintenance of function, rather than improvement, in a population that tends to become increasingly frail and dependent. Therefore, time to deterioration, or a dichotomous global outcome such as "improved or maintained independence" compared with "deterioration or death" [**28**, 41, 42], might be more appropriate measures of intervention effects as they would include all randomised patients, not just those still alive at follow-up. Also, it may be that studies with interventions of longer duration would identify a larger effect on independence in ADL. We recognise that physical rehabilitation is sometimes intended to improve other outcomes not considered here, such as mental health, social interaction, mood and well-being [**13**, 43, 44].

The cluster RCTs in this review had small effective sample sizes because the intra-cluster correlation coefficient (ICC) of 0.38 is very high. A cluster design can be useful for preventing performance bias and intervention contamination between participants. However, the large ICC means very large samples will be needed in future trials, particularly where each cluster is large. The estimated ICC is derived from only two UK studies. It is plausible that different ICCs would be found in different settings and countries. Therefore, it is important that future cluster studies report adjusted results and an ICC.

The measurement properties of commonly used ADL scales are known to be problematic [45, 46], as they often lack unidimensionality and other requisite properties to allow valid summation. This review was constrained by the scales that have been used in the existing literature. Over the past 20 years, great advances have been made in the field of rehabilitation measurement through the introduction of item response theory [47]. This allows more meaningful scores to be developed, with increased sensitivity. Future studies should employ measures with the best psychometric properties, instead of relying on traditional scales.

This review has a number of limitations. Bias may have increased the estimate of effect on ADL. None of the studies included in the meta-analysis had a low risk of bias across all the domains assessed. One analysis suggested differences in assessed risk of bias were not associated with differences in effect size. However, other analyses linked studies with a large number of participants, and studies with low attrition, to small effect sizes, both of which are indicative of bias [**15**]. A post-hoc sensitivity analysis that included only the five studies with a large sample and low attrition did not estimate a statistically significant mean effect of rehabilitation. Many of the included trials are proof of concept studies that are likely to find a greater effect than would be achieved in routine practice, because of the enthusiasm and skill of those delivering the intervention and its fit with the local context. While underestimation could be a problem if contamination occurred, there was no evidence that these studies were so affected, either in the study reports or when comparing results of cluster trials to the RCTs in which contamination could occur. Underestimation of efficacy can be a problem when those unlikely to respond or those who do not participate in the intervention are included. However, this is unlikely to have been the case in these studies as all but one limited inclusion to a subset of participants, and when participants did drop out they were typically excluded from the analyses.

The generalisability of these results to residents of long-term care facilities is unclear. Only one quarter of residents in participating facilities were recruited [**13**], as some studies restricted participation to those meeting some minimum level of functioning, while others were restricted to those with some degree of dependence in ADL. This highlights some of the diversity within the long-term care population and also in the aims and content of the interventions. However, we have reported characteristics of the included participants, which may assist in identifying those residents to which the results are most relevant. Despite this, the lack of information about the nature of the control conditions in many of the studies limits our understanding of the contexts in which the results would be applicable.

## Conclusion

Physical rehabilitation appears to have a small effect on ADL in older people residing in long-term care facilities. However, this finding should be interpreted with caution as inferences are limited by study bias. Further well-designed, large-scale studies are still required.

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## Conflicts of interest

Anne Forster and John Young have conducted a National Institute for Health Research (NIHR) development programme to investigate activity in care homes. They have received a NIHR

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PLEASE NOTE: The very long list of references supporting this review has meant that only the most important are listed here and are represented by bold type throughout the text. The full list of references is available on the journal website http://www.ageing.oxfordjournals.org/ as appendix 1

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## Figures and tables

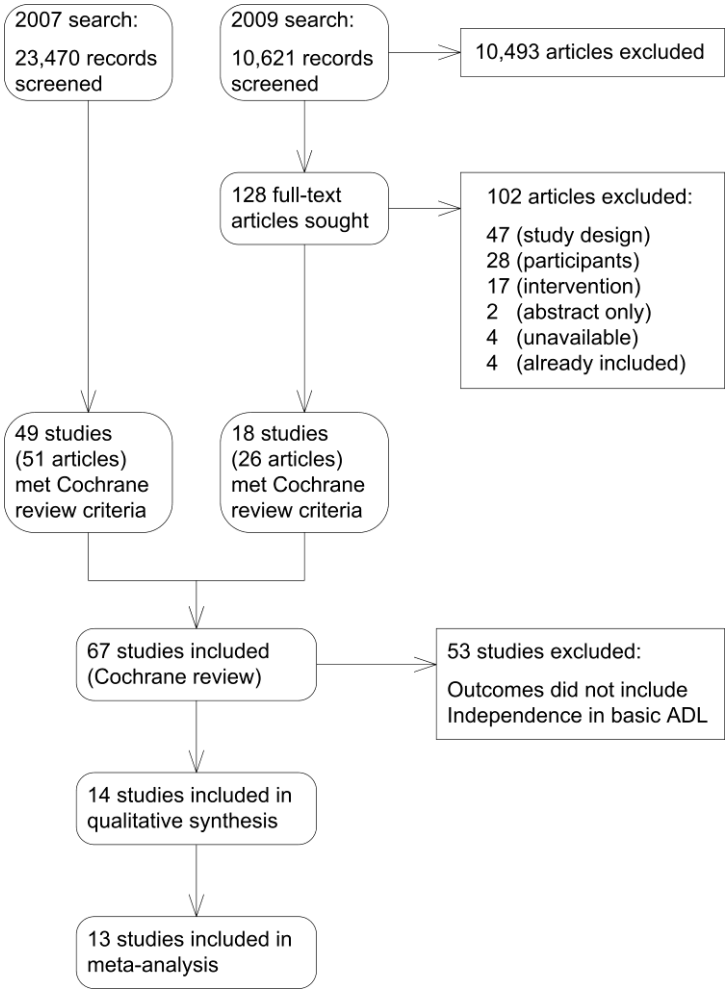


**Figure 1.Flow chart for systematic review**

**Table 1. Scoring and domains of included outcome measures.**

| Outcome measure | Scale range | Independence score* | Feeding | Dressing | Bathing | Grooming | Toilet use | Continence | Mobility | Transfers | Communication | Cognition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Barthel Index [**35**] | 0-20 | > | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| Functional Independence Measure [**36**] | 18-126 | > | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Katz Index of Independence in ADL [**37**] | 0-6 | > | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | | |
| Physical Self-Maintenance Scale [**38**] | 0-6 | > | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | |
| Minimum Data Set (eight item summary) [**21**] | 0-40 | < | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | |

* Higher scores (>) or lower scores (<) represent greater independence.

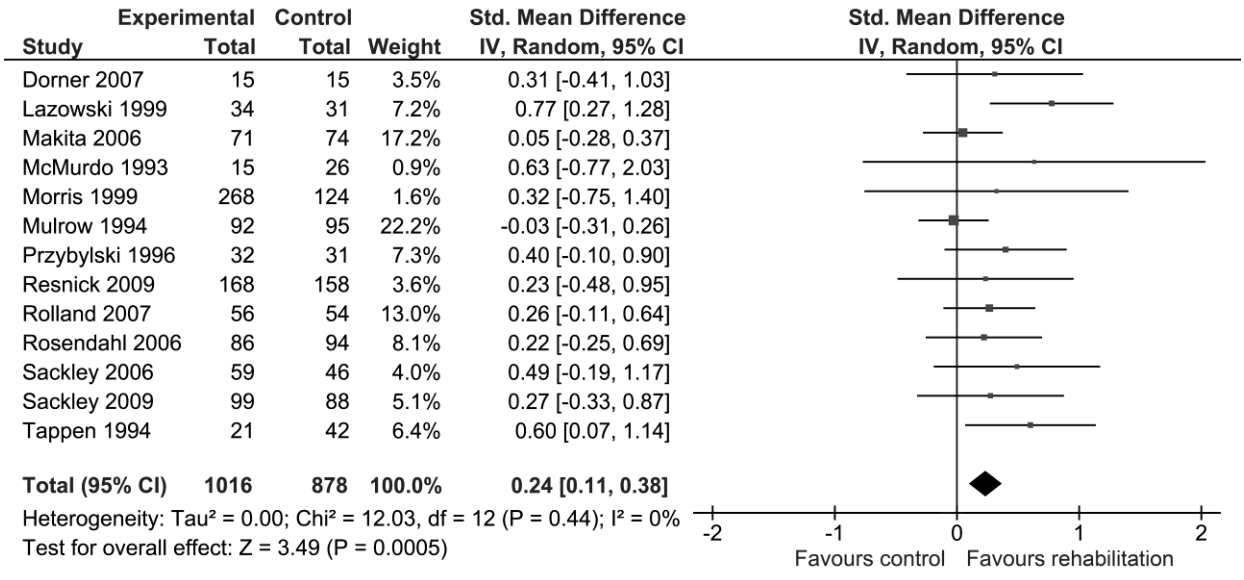


**Figure 2.Forest plot of standardised mean difference between rehabilitation and control groups (positive favours rehabilitation)**

**Table 2 Subgroup analyses**

| Subgroups | Studies | Participants | Effect estimate [95% CI] | Test for subgroup differences |
|---|---|---|---|---|
| 1 Age | | | | |
| 1.1 younger (mean age < 85 years) | 9 | 1427 | 0.30 [0.11, 0.49] | P = 0.43 |
| 1.2 older (mean age 85+ years) | 4 | 467 | 0.18 [-0.07, 0.42] | |
| 2 Duration of intervention | | | | |
| 2.1 shorter (<3 months) | 3 | 327 | 0.10 [-0.12, 0.32] | P = 0.11 |
| 2.2 longer (3+ months) | 10 | 1567 | 0.33 [0.16, 0.50] | |
| 3 Mode of delivery | | | | |
| 3.1 group | 8 | 882 | 0.31 [0.13, 0.49] | P = 0.29 |
| 3.2 individual | 6 | 1136 | 0.16 [-0.05, 0.36] | |
| 4 Intensity | | | | |
| 4.1 high | 6 | 820 | 0.26 [0.01, 0.50] | P = 0.87 |
| 4.2 low | 3 | 249 | 0.30 [-0.13, 0.73] | |
| 5 Risk of bias | | | | |
| 5.1 lower risk of bias | 2 | 292 | 0.37 [-0.08, 0.82] | P = 0.62 |
| 5.2 higher risk of bias | 11 | 1602 | 0.25 [0.09, 0.41] | |
| 6 Number of participants | | | | |
| 6.1 N<100 | 6 | 367 | 0.54 [0.29, 0.79] | P = 0.005 |
| 6.2 N>=100 | 7 | 1527 | 0.12 [-0.05, 0.28] | |
| 7 Attrition | | | | |
| 7.1 <20% lost to follow-up | 7 | 1118 | 0.15 [-0.01, 0.31] | P = 0.05 |
| 7.2 >20% lost to follow-up | 6 | 776 | 0.45 [0.20, 0.69] | |
| 8 Trial design | | | | |
| 8.1 RCT | 7 | 663 | 0.28 [0.06, 0.50] | P = 0.90 |
| 8.2 Cluster RCT | 6 | 1231 | 0.30 [0.02, 0.58] | |
| 9 Outcome measure | | | | |
| 9.1 Barthel Index | 6 | 869 | 0.33 [0.06, 0.60] | |
| 9.2 FIM | 4 | 303 | 0.32 [-0.02, 0.67] | |
| 9.3 Katz ADL | 2 | 297 | 0.09 [-0.19, 0.37] | P = 0.51 |
| 9.4 Minimum Data Set | 1 | 392 | 0.32 [-0.75, 1.40] | |
| 9.5 Physical Self-Maintenance Scale | 1 | 63 | 0.60 [0.07, 1.14] | |

# Appendix: Methods

## Search strategy and selection criteria

We sought to identify studies that met the following criteria:

- RCTs or cluster RCTs
- Participants were older adults (mean age >60 years) living permanently in long-term care facilities

    Long-term care facilities were defined as providing all of the following [14]:

    - communal living facilities for long-term care
    - overnight accommodation
    - nursing or personal care
    - provision for people with illness, disability or dependence
- Intervention included physical activity designed to improve physical condition
- Reported outcomes included a measure of independence in basic ADL

We developed a search strategy in collaboration with the Cochrane Stroke Group that we adapted to each database. We searched 19 databases on or after the 18th December 2009 without restriction to language or date: The Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Cochrane Other Reviews and Methods Database, MEDLINE, EMBASE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Allied and Complementary Medicine Database (AMED), Physiotherapy Evidence Database (PEDro), Applied Social Science Index and Abstracts(ASSIA), International Bibliography of Social Sciences (IBSS), PsycINFO, Database of Abstracts of Reviews of Effects (DARE), Health Management Information Consortium Database (HMIC), NHS Economic Evaluation Database (NHS EED), Health Technology Assessment (HTA) Database, ISI Web of Knowledge, Google Scholar, Index to Theses, Proquest Dissertations and

Theses. We also searched trials and research registers, conference proceedings, checked reference lists, and contacted relevant authors, researchers and other Cochrane entities.

## Data collection and analysis

Two researchers independently assessed all identified study titles and, when required, the accompanying abstracts. All potentially relevant studies were obtained and assessed by at least two researchers according to inclusion criteria. Disagreements were resolved at a consensus meeting.

Two researchers independently extracted data into a database; a third researcher combined these data-sets, discussing any discrepancies with the other researchers. Risk of bias was assessed using the Cochrane Collaboration's tool for assessing risk of bias [**15**]. This assesses bias across six domains: selection bias (due to allocation sequence generation and concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessors), attrition bias (due to incomplete outcome data), reporting bias (due to selection of presented results) and other bias.

There is evidence that scales of independence in ADL can be calibrated as linearly transformable versions of the same construct [16]. Due to the limitations of the available data, such transformations were not feasible, but this suggests the scales measure the same outcome, which is required to combine them using the standardised mean difference approach [**15**]. The scales were treated as if they were continuous. Where cluster trials presented adjusted analyses we used these values, otherwise we adjusted using an estimate of the intra-cluster correlation coefficient (ICC) derived from other included studies. We used measures from the end of the intervention unless otherwise stated. Measures of treatment effect using Hedges' adjusted *g* version of the standardised mean difference (SMD) and the standard error of this difference (SE) were combined in meta-analysis using a random-effects model [**15**]. Where a study presented multiple outcomes using different measures or different rehabilitative interventions, we used the average of these estimates.

To explore possible reasons for heterogeneity in estimates of effect we conducted sub-group analyses of age (mean < 85 years vs. 85+), duration of intervention (<3 months vs. 3+ months), mode of delivery (group vs. individual) and intensity (high vs. low). We explored whether estimates of effect were sensitive to aspects of study design or conduct by comparing risk of bias (lower (studies with the most domains judged low risk of bias) vs. higher (others)), number of participants (<100 vs. 100+), proportion of missing data (<20% attrition vs. 20%+), study design (RCT vs. cluster RCT) and instrument used to measure independence in ADL.