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Circuit class therapy for improving mobility after stroke.
Cochrane Database of Systematic Reviews 2017, Issue 6. Art. No.: CD007513.
DOI: 10.1002/14651858.CD007513.pub3.

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[Intervention Review]

Circuit class therapy for improving mobility after stroke

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Editorial group: Cochrane Stroke Group.
Publication status and date: Edited (no change to conclusions), published in Issue 6, 2017.

Citation: English C, Hillier SL, Lynch EA. Circuit class therapy for improving mobility after stroke. *Cochrane Database of Systematic Reviews* 2017, Issue 6. Art. No.: CD007513. DOI: 10.1002/14651858.CD007513.pub3.

ABSTRACT

Background

Circuit class therapy (CCT) offers a supervised group forum for people after stroke to practise tasks, enabling increased practice time without increasing staffing. This is an update of the original review published in 2010.

Objectives

To examine the effectiveness and safety of CCT on mobility in adults with stroke.

Search methods

We searched the Cochrane Stroke Group Trials Register (last searched January 2017), CENTRAL (the *Cochrane Library*, Issue 12, 2016), MEDLINE (1950 to January 2017), Embase (1980 to January 2017), CINAHL (1982 to January 2017), and 14 other electronic databases (to January 2017). We also searched proceedings from relevant conferences, reference lists, and unpublished theses; contacted authors of published trials and other experts in the field; and searched relevant clinical trials and research registers.

Selection criteria

Randomised controlled trials (RCTs) including people over 18 years old, diagnosed with stroke of any severity, at any stage, or in any setting, receiving CCT.

Data collection and analysis

Review authors independently selected trials for inclusion, assessed risk of bias in all included studies, and extracted data.

Main results

We included 17 RCTs involving 1297 participants. Participants were stroke survivors living in the community or receiving inpatient rehabilitation. Most could walk 10 metres without assistance. Ten studies (835 participants) measured walking capacity (measuring how far the participant could walk in six minutes) demonstrating that CCT was superior to the comparison intervention (Six-Minute Walk Test: mean difference (MD), fixed-effect, 60.86 m, 95% confidence interval (CI) 44.55 to 77.17, GRADE: moderate). Eight studies (744 participants) measured gait speed, again finding in favour of CCT compared with other interventions (MD 0.15 m/s, 95% CI 0.10 to 0.19, GRADE: moderate). Both of these effects are considered clinically meaningful. We were able to pool other measures to demonstrate the superior effects of CCT for aspects of walking and balance (Timed Up and Go: five studies, 488 participants, MD -3.62 seconds, 95% CI -6.09 to -1.16; Activities of Balance Confidence scale: two studies, 103 participants, MD 7.76, 95% CI 0.66 to 14.87). Two other pooled balance measures

failed to demonstrate superior effects (Berg Blance Scale and Step Test). Independent mobility, as measured by the Stroke Impact Scale, Functional Ambulation Classification and the Rivermead Mobility Index, also improved more in CCT interventions compared with others. Length of stay showed a non-significant effect in favour of CCT (two trials, 217 participants, MD -16.35, 95% CI -37.69 to 4.99). Eight trials (815 participants) measured adverse events (falls during therapy): there was a non-significant effect of greater risk of falls in the CCT groups (RD 0.03, 95% CI -0.02 to 0.08, GRADE: very low). Time after stroke did not make a difference to the positive outcomes, nor did the quality or size of the trials. Heterogeneity was generally low; risk of bias was variable across the studies with poor reporting of study conduct in several of the trials.

Authors' conclusions

There is moderate evidence that CCT is effective in improving mobility for people after stroke - they may be able to walk further, faster, with more independence and confidence in their balance. The effects may be greater later after the stroke, and are of clinical significance. Further high-quality research is required, investigating quality of life, participation and cost-benefits, that compares CCT with standard care and that also investigates the influence of factors such as stroke severity and age. The potential risk of increased falls during CCT needs to be monitored.

PLAIN LANGUAGE SUMMARY

Circuit class therapy for improving mobility after stroke

Review question

Is circuit class therapy better than conventional physiotherapy for improving people's walking after a stroke?

Background

After stroke, people can have difficulty walking. They may become slower, only manage short distances, and may need assistance. They may lose balance more easily and be more fatigued. This can mean they walk even less, and so walking ability can worsen. Rehabilitation can help improve walking, but it is hard to access, particularly later after stroke. Circuit class therapy involves working in groups (rather than individually with a therapist), and doing specific practice of meaningful tasks, and may offer a solution that is more accessible.

Study characteristics

This is an update of the original review in 2010. We considered studies comparing circuit class therapy with conventional therapy for people with stroke, and included only high-quality studies with a low risk of being biased. We were interested in studies that compared these two approaches and their effects on the way people walk, how far, how fast, and how independently. We also looked for studies that investigated if the circuit classes were more or less likely to be harmful than conventional approaches. The evidence is current to January 2017.

Main results

We found seventeen studies, involving 1297 participants, that compared circuit class rehabilitation with usual care or sham rehabilitation. Most trials reported the benefits of circuit classes for improving walking ability. More specifically, we combined the results from the studies and found moderate evidence that circuit classes were more effective in improving the person's ability to walk further, more independently, and faster and, in some cases, to balance more easily and confidently when compared with other types of therapy. There was a suggestion that people might fall more often in the circuit classes, and that they may be able to get home from rehabilitation hospital more quickly, but these two aspects were not confirmed using statistics. We also found that the positive effects of the circuit classes were experienced equally by people who had had their stroke more than a year ago compared with people who had had their stroke within the year. This means people can continue to improve longer after their stroke than was previously reported. More research is needed to see if it works for all people with any severity of stroke and if some tasks are better to practise than others.

Quality of the evidence

The quality of the studies overall was acceptable, given it is difficult to keep some aspects tightly controlled in rehabilitation studies. However, we have downgraded the quality rating to 'moderate' to acknowledge that some trials have the potential for bias.

Summary of findings for the main comparison. Circuit class therapy compared with other intervention for improving mobility

Circuit class therapy compared with other intervention for improving mobility

Patient or population: people with stroke

Settings: in hospital or community

Intervention: mobility-related circuit class therapy

Comparison: any other intervention

Outcomes	Illustrative comparative effects (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed effect	Absolute effect				
	Other intervention	Mobility-related circuit class therapy				
Walking capacity: 6mWT Continous measure of distance walked in 6 minutes in m	The mean 6mWT distance ranged across control groups from 106 m to 441 m	The mean 6mWT distance in the intervention groups was 60.86 m further (44.55 to 77.17)		835 (10)	⊕⊕⊕⊖ **moderate**	Applicable: difference greater than minimal clinically important difference (MDC) = 34.4m Eng 2004, and 95% CI of difference does not cross MDC Test for differences between subgroups 'early' versus 'later' (< 1 year vs > 1 year post stroke) were not significant. Some studies have unclear risk of bias (downgraded)
Walking speed Continuous measure of walking speed measured over a short distance in m/s	The mean gait speed ranged across control groups from 0.43 m/s to 1.3 m/s	The mean gait speed in the intervention groups was 0.15 m/s faster (0.10 to 0.19)		744 (8)	⊕⊕⊕⊖ **moderate**	Applicable: difference greater than MDC = 0.06 m/s Perera 2006, and 95% CI of difference does not cross MDC Some studies have unclear risk of bias (downgraded)
Balance and mobility	The mean speed ranged across control groups	The mean speed in the intervention group was 3.62		488 (5)	⊕⊕⊖⊖ **low**	Applicable: somewhat as difference is not greater than MDC (8 s or 28%) (downgraded).

Timed up and go test. Standing up, walking, returning to sit down in seconds	from 15 s to 28.6 s.	s faster (-6.06 to -1.16)				Some studies have unclear risk of bias (downgraded)
Independence in mobility Functional ambulation classification. Indicates need for assistance/not to safely mobilise	The number of independent participants ranged across the control groups from 2 to 92	The odds ratio of independent classifications in favour of the intervention group was 1.91 (1.01 to 3.6)		469 (3)	⊕⊕⊕⊖ **moderate**	Applicable: better odds of independence in walking is clinically useful. Some studies have unclear risk of bias (downgraded)
Physical ability Stroke Impact Scale. A self report of overall physical ability (subscale of total Impact)	The mean score for the control groups ranged from 55.4 to 83.73 points (higher is better)	The mean score for the intervention groups was 2.91 points higher (0.00 to 5.82)		437 (2)	⊕⊕⊖⊖ **low**	Applicable: only somewhat as the mean change score should be 4.5 points to be regarded as clinically important (downgraded) Only two trials (downgraded)
Adverse events (falls) from all available trials Counts of numbers of falls	**High risk population** **91.4 per 1000**	**134 per 1000**	**RD 0.03 (-0.02 to 0.08)**	815 (8)	⊕⊖⊖⊖ **very low**	Applicable: 8 out of 17 studies reported falls; 4 of these studies reported no falls in either group. Only small number of studies reported that falls occurred (low event rate with low reporting), wide CIs Difference not statistically significant (downgraded) Some studies have unclear risk of bias (downgraded) Heterogeneity $I^2 > 50\%$, (downgraded)

CI: confidence interval; **RD:** risk difference; **MDC:** minimal detectable change

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of effect.
Moderate quality: We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of effect, but there is a possibility that it is substantially different.
Low quality: OUr confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of effect.
Very low quality: We have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of effect.

BACKGROUND

Description of the condition

Stroke is the second most common cause of death globally, and was the third most common cause of disability-adjusted life-years worldwide in 2010 (Feigin 2014). The absolute numbers of people with stroke and the overall global burden of stroke are high and, despite medical advances in high-income countries, these numbers are increasing steadily (Feigin 2014). Disability from stroke can negatively affect people's relationships (Lynch 2008a), the ability to live in the community, and the ability to participate in work and leisure activities. Stroke rehabilitation has been described as a holistic management plan, which is directed towards "enabling a person with impairment to reach their optimal physical, cognitive, emotional, communicative and/or social functional level" (Dawson 2013, p4). In terms of physical function, there are clear benefits from the provision of physical rehabilitation after stroke (Pollock 2014). With increasing numbers of people having strokes, post-stroke rehabilitation services are in high demand.

Rehabilitation after stroke can be provided in inpatient settings, in peoples' homes, or in community clinics. The financial costs associated with stroke are substantial: for instance, the average per-person costs of stroke in 2012 in Australia was AUD 27,709 (Deloitte Access Economics 2013), and the burden of disease costs in the USA has been estimated at USD 34 billion per year (Mozaffarian 2015). While there is evidence that rehabilitation at home may be more cost-effective than other models of service delivery (Hillier 2010), this is not a feasible service for many people with stroke. Given the high demand for services and high costs associated with delivering post-stroke care, there is pressure on rehabilitation services to provide evidence-based therapies that are also cost effective.

Description of the intervention

Group circuit class therapy (CCT) is a model of physical therapy delivery wherein participants are given the opportunity to practice active task-specific exercises (i.e. functional activities) in an intensive manner. The first trials investigating the feasibility of providing physical therapy to patients in groups rather than the traditional one-therapist-to-one-patient model were published in the late 1990s (Taskinen 1999; Teixeira-Salmela 1999). The key components of CCT are that physical therapy is provided in groups (more than two participants per therapist) and there is a focus on repetitive practise of functional tasks and exercises that are continually progressed as the participant's function improves (English 2007; Van de Port 2012; Wevers 2009). CCT may comprise either a series of workstations arranged in a circuit (Van de Port 2012; Wevers 2009) or a series of individualised activities within a group setting (English 2007; English 2015). CCT differs from physiological exercise programmes designed to improve strength or aerobic fitness because, although many CCT exercises may have a strength or fitness component, the primary focus is on specific training of everyday motor tasks.

CCT can be directed towards a range of post-stroke impairments and has been used to improve the use of hemiparetic upper limbs (Blennerhassett 2004), or to improve both mobility and upper limb impairments within the one circuit class session (English 2007; English 2015). However, the majority of studies have investigated the use of CCT for improving mobility (the ability to stand, walk, or run) so mobility-tailored CCT is the focus of this review.

How the intervention might work

Physical therapy provided to people with stroke for 30 minutes to 60 minutes per day, five to seven days per week, results in significant improvements in independence and motor function compared with no therapy (Pollock 2014). Accordingly, many national clinical guidelines for stroke recommend that people with stroke spend a minimum of between 30 minutes and three hours per day in therapy during inpatient rehabilitation (Intercollegiate Stroke Working Party 2012; Jauch 2013; Lindsay 2010; National Stroke Foundation 2010; Stroke Foundation of New Zealand 2010). Data modelling work has demonstrated that increased time scheduled for therapy is associated with significant post-stroke improvements in function (Lohse 2014). Further evidence regarding the benefits of increased time in therapy was provided from a recently updated meta-analysis of clinical trials of physiotherapy after stroke (Verbeek 2014). The meta-analysis included 80 trials that investigated the effect of providing increased intensity (hours spent) of physiotherapy, and found that increasing time in therapy after stroke is associated with significant, positive effects on walking speed, balance, and activities of daily living. In order to achieve significant positive effects at the body-function level as well as the activities and participation level, an increase of 17 hours of therapy provided over 10 weeks is necessary (Verbeek 2014). The group nature of CCT interventions potentially allows a greater amount of therapy to be provided to patients within a finite period of time without increasing staffing requirements.

A recent Cochrane Review on physiotherapy for improving mobility after stroke reported that no approach of physiotherapy is clearly more effective than other approaches (Pollock 2014). The review also found that physiotherapy appears to be most beneficial when a mixture of different approaches are provided that are tailored for each patient. Interventions that have proven effectiveness in improving mobility outcomes for people with stroke include balance training (Verbeek 2014), combined strength and cardiovascular training (Verbeek 2014), and treadmill training for people who are able to walk independently (Mehrholz 2014). CCT can potentially improve mobility outcomes as the aforementioned interventions can be incorporated into CCT, and all activities prescribed within CCT are routinely tailored to each participant.

There may be benefits of CCT related to the peer support and social interaction provided by the group environment. Depression after stroke is common, affecting one third of people in the first year following stroke (Hackett 2008). Several small qualitative studies have found benefits to stroke survivors from participating in group activities with peers in terms of learning new coping mechanisms (Morris 2012), experiencing an increased sense of independence and well-being (Morris 2012), and reducing post-stroke depression (Stroke Recovery Canada 2009).

The format of CCT is conducive for optimal motor learning after stroke. Given the group nature of the CCT format, participants will usually be prescribed certain activities to perform semi-supervised or independently, and other activities to perform with assistance of a therapist. When participants are performing the independent activities, the nature of the task-specific exercise should ensure their attention is on the overall movement outcome (external focus)

rather than the individual body part or joint movements (internal focus). Attention to external foci has been associated with better motor-learning outcomes (Van Vliet 2006; Wulf 2010). The presence of a therapist at each CCT session allows for extrinsic feedback to be given to participants, which is an important contributor for optimal motor learning (Sigrist 2013; Wulf 2010). Further, CCT allows participants to observe other stroke survivors who are learning new motor tasks, which is another mechanism to facilitate motor learning (Wulf 2010).

Why it is important to do this review

Given the fiscal constraints of healthcare systems, rehabilitation services cannot simply increase the amount of therapy provided to people with stroke by scheduling more frequent or longer one-to-one therapy sessions, because this involves significant increases in staffing costs. Instead, it is important that novel cost-effective models of providing increased intensity of therapy are developed, researched, and implemented. CCT has the potential to be an effective means of providing a greater amount of physical therapy for people with stroke both in hospital and community settings. When the clinical effectiveness of CCT is established, then cost implications of this model of therapy provision can be investigated. This is an update of the original review in 2010 which found that there was evidence to support the use of CCT for improving mobility after stroke.

OBJECTIVES

To examine the effectiveness and safety of CCT on mobility in adults with stroke.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs) comparing CCT with no therapy, sham therapy, or another therapy modality. The earlier review included quasi-randomised trials due to the paucity of studies. This was not necessary in this update.

Types of participants

We included studies of adults (18 years and older) with stroke (all types, severity, and stages of stroke/rehabilitation).

Types of interventions

We defined CCT as an intervention that involves participants receiving physical rehabilitation in a group environment, with a staff-to-client ratio of no greater than 1:3 (that is, no more than one staff member per three clients). We included studies that provided a minimum of once-weekly CCT sessions for a minimum of four weeks. We only included studies that reported interventions with a focus on repetitive (within session) practise of functional tasks arranged in a circuit, with the aim of improving mobility. We excluded studies of interventions that included exercises solely aimed at improving impairment (such as strengthening, range of motion, or cardiovascular fitness).

Types of outcome measures

We evaluated outcome measures at post-intervention and at follow-up wherever available (e.g. three to six months post-intervention). We did not consider outcomes taken after a single circuit class.

Primary outcomes

In this update the primary outcome of interest was walking capacity as measured using the Six Minute Walk Test (distance walked in six minutes: 6mWT). This is a clinically-sensitive measure with demonstrated functional benefit for the person with stroke.

Secondary outcomes

Other measures of walking and standing ability including:

- walking speed measured over a short distance (e.g. 5 m or 10 m walk test);
- functional mobility measures such as the Timed Up and Go (TUG) or the Rivermead Mobility Index (RMI);
- measures of standing balance, including the Step Test, Berg Balance Scale or Functional Reach Test.

Measures of impairment, such as:

- lower limb strength; and
- range of motion.

Measures of activity limitation, such as:

- instrumental activities of daily living; and
- personal care.

Measures of participation restriction, such as:

- health-related quality of life.

Other measures, such as:

- length of hospital stay;
- adverse events (including mortality);
- self-reported satisfaction;
- locus of control;
- economic indicators.

Summary of inclusion criteria

- Human participants diagnosed with stroke (haemorrhage or infarct), of any severity/stage/setting (e.g. early: less than six months; or later: more than six months)
- Eighteen years of age or older
- Receiving CCT as defined
- Outcomes evaluated in domains as defined
- RCT

Search methods for identification of studies

See the 'Specialized register' section in the Cochrane Stroke Group module. We included all languages, and did not impose any date limits. To improve sensitivity we did not include a trials filter. We arranged for the translation of articles where necessary.

Electronic searches

We searched the Cochrane Stroke Group Trials Register, which was last searched by the Managing Editor in January 2017. We searched for additional articles published since the previous Cochrane

systematic review on this topic from January 2008 onwards. Databases searched include the Cochrane Central Register of Controlled Trials (CENTRAL) (in the Cochrane Library 2016, Issue 12, Appendix 1), MEDLINE (in OVID, 1950 to January 2017, Appendix 2), Embase (1980 to January 2017, Appendix 3), CINAHL (1982 to January 2017, Appendix 4), PsycINFO (last searched January 2017, Appendix 5), AMED (1985 to January 2017, Appendix 6), SPORTDiscus (1949 to January 2017, Appendix 7), AGELINE (1978 to March 2015), Current Contents (last searched January 2017), Australasian Medical Index (AMI, 1968 to June 2016), NLM GATEWAY (gateway.nlm.nih.gov, last searched June 2016 for 2014 update), Latin American & Caribbean Health Sciences Literature (LILACS, 1982 to June 2016), IndMed (1985 to January 2017), Educational Resources Information Center (ERIC, 1967 to June 2016), and the Physiotherapy Evidence Database (PEDro, www.pedro.org.au, last searched January 2017). Unique search strings are included in the Appendices, and where not included are adaptations.

Searching other resources

We used the MEDLINE (Ovid) search developed by the Cochrane Stroke Group Information Specialist and adapted it to search the other databases. We included all languages, and imposed no date limits. As the subject area of this review is quite specific we did not include a trials filter. This increased the sensitivity of the search.

In an effort to identify further published, unpublished and ongoing studies, we:

- searched for proceedings from stroke-related conferences that were peer-reviewed and published in the above databases until 2016;
- searched reference lists (from salient articles, journals and books) and unpublished theses;
- contacted authors of published trials and other experts in the field;
- searched the following clinical trials and research registers:
  - World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (apps.who.int/trialsearch/);
  - US National Institutes of Health Ongoing Trials Register, ClinicalTrials.gov (www.clinicaltrials.gov/);
  - Computer Retrieval of Information on Scientific Projects (commons.era.nih.gov/common);
  - ISRCTN Registry www.isrctn.com/ (formerly the Current Controlled Trials);
  - National Institute of Neurological Disorders and Stroke (www.ninds.nih.gov/);
  - National Rehabilitation Information Centre (Naric) (including REHABDATA) (www.naric.com/);
  - Stroke Trials Directory - the Internet Stroke Center (www.strokecenter.org/trials).

Data collection and analysis

Selection of studies

We retrieved papers from the identified lists on the basis of title/abstract, reviewing them against the established criteria for inclusion. If all criteria were met (that is, answers to the five criteria were 'yes' or 'unsure') we retrieved the study in full and reviewed it for final inclusion and then for methodological quality and data extraction. If we disagreed on any aspect of study inclusion we reached consensus through discussion and had a third review author available for consultation if consensus could not be reached.

Data extraction and management

We independently entered data into the Review Manager software, RevMan 5.3 (RevMan 2014), and included full citation details of the study, objectives, design, length, assessment time points, number and characteristics of participants (inclusion and exclusion criteria), description of the intervention, outcome measures, intention-to-treat analysis, withdrawals and loss to follow-up, and adverse events. If we disagreed on any aspect of data extraction or quality evaluation, we reached consensus through discussion and had a third review author available for consultation if consensus could not be reached.

Assessment of risk of bias in included studies

We independently assessed the quality of the studies to be included. We assessed the methodological quality of the included studies for risk of bias using the criteria recommended in section 8 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011) in six domains: sequence generation, allocation concealment, blinding of participants, personnel and outcome assessors, incomplete outcome data, selective reporting and 'other'. We defined 'other' as adequate sample size, based on supplied power calculations. We gave studies an overall summary of the risk of bias for each important outcome (across domains), as well as within and across studies using three levels: low, unclear, or high risk of bias. We also gave a descriptive report on the overall risk of bias in relation to the findings from the meta-analyses.

Measures of treatment effect

We extracted and analysed data to calculate risk ratio (RR) or mean difference (MD) and 95% confidence intervals (CI). This required the identification of the number of participants in each group in each trial and the total number (for dichotomous data), and the number of participants plus the mean and standard deviations for each group (for continuous data).

Unit of analysis issues

We considered studies with non-standard designs, for example, cluster randomised trials, if they were assessed as having a low risk of bias. We only considered randomised cross-over trials prior to cross over (irrespective of wash-out periods as the changes are assumed to be permanent) and if the study authors provided an analysis of results for the first phase.

Dealing with missing data

We contacted study authors to request appropriate data for meta-analyses if these were not adequately reported in the retrieved paper. We considered intention-to-treat analysis as part of the risk of bias assessment and recorded loss to follow-up.

Assessment of heterogeneity

We assessed statistical heterogeneity both visually and using the I^2 statistic (Higgins 2003). Where I^2 was greater than 50% we used random-effects rather than a fixed-effect analysis. We also evaluated clinical heterogeneity (clinical and methodological diversity).

Assessment of reporting biases

We minimised reporting biases by the comprehensive search strategies, which had no date or language limits. However, where appropriate we could also examine this statistically via funnel plots and tests for asymmetry if there were sufficient studies (recommended more than 10; Sterne 2011).

Data synthesis

We conducted a meta-analysis with appropriate data. We considered the degree of heterogeneity to determine whether to use fixed-effect or random-effects analyses.

Subgroup analysis and investigation of heterogeneity

We considered performing subgroup analyses to establish effectiveness relative to gender, chronicity, age or stroke severity (respectively men versus women; early (less than one year post-stroke) versus late (more than one year post-stroke); young adults versus older; mild/moderate versus severe stroke, if sufficient data were available.

Sensitivity analysis

We conducted sensitivity analyses to determine if pooling results from large trials (more than 100 participants) led to different results compared with pooling data from small trials (fewer than 100 participants), or if trials with low versus high risk of bias influenced the results, when a sufficient number of trials were available.

GRADE assessment and 'Summary of findings' tables

We presented the main results of the review in Summary of findings for the main comparison for the comparison of CCT versus 'other' interventions. We reported the outcome measure of walking capacity (6mWT) as the primary outcome; we also included other secondary outcomes in the table that had a sufficient body of evidence (number of trials/number of participants) in recognition that low numbers in either or both of these inevitably leads to a 'very low' GRADE designation.

A 'Summary of findings' table presents information about the certainty of the evidence, the size of the effect of the intervention examined, and the sum of available data for the main outcomes. The 'Summary of findings' table also includes an overall grading of the evidence related to each of the main outcomes using the GRADE approach (GRADE 2013). This defines the certainty or confidence in a body of evidence that an estimate of effect or association is close to the true quantity of specific interest. This certainty involves consideration of within-trial risk of bias (methodological quality), applicability of evidence, heterogeneity, precision of effect estimates, and risk of publication bias (Higgins 2011). When making decisions for the risk of bias, we downgraded only when we had classed studies as being at high risk of bias for one or more domains or they were classed as being at unclear risk of bias for both domains that contribute to selection bias, or both (GRADE 2013).

RESULTS

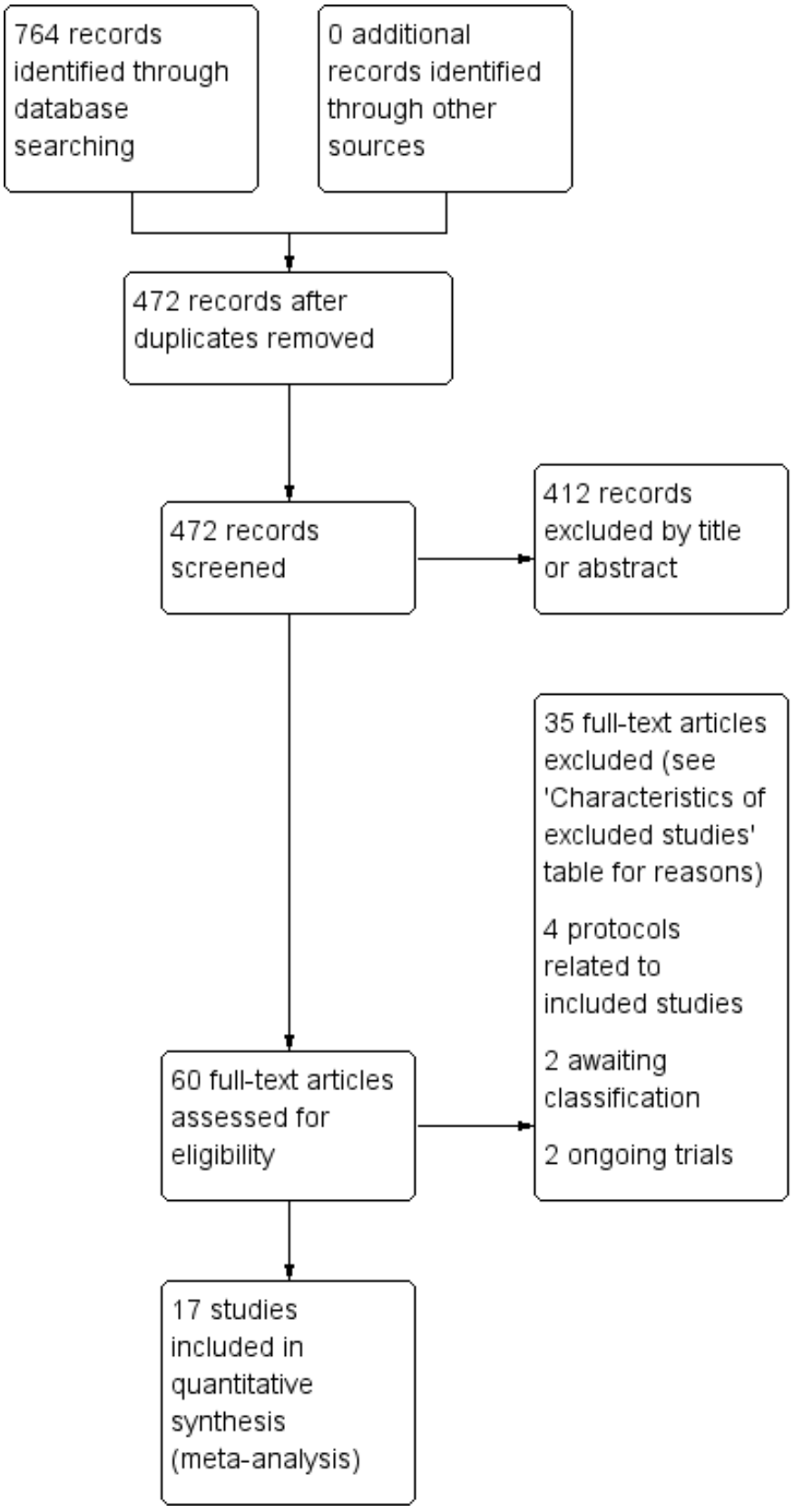
Description of studies

See Characteristics of included studies and Characteristics of excluded studies

Results of the search

We retrieved 101 potential trials in full from the search, of which we included 17 in this review (Figure 1). Twelve were new studies published between 2010 and 2015. Five studies were included from the previous review (Blennerhassett 2004; Dean 2000; Marigold 2005; Mudge 2009a; Pang 2005). We excluded one study from the previous review in this update as it was a pseudo-randomised trial (English 2007).

Figure 1. PRISMA flow diagram



Included studies

The 17 included trials were all conducted between 2000 and 2015; four in Australia (Blennerhassett 2004; English 2015; Dean 2012; Marsden 2010), four in Canada (Dean 2000; Marigold 2005; Pang 2005; Tang 2014), two in Korea (Song 2015; Kim 2016a) and the UK (Harrington 2010; Moore 2015) , and one each in Germany (Outermans 2010), India (Verma 2011), , the Netherlands (Van de Port 2012), New Zealand (Mudge 2009a), and Sweden (Holmgren 2010). Four trials were conducted in an inpatient hospital setting (Blennerhassett 2004; English 2015; Song 2015; Verma 2011). The remaining 13 trials were conducted in community settings. A total of 1297 participants were included with sample sizes varying from 12 to 250 participants. Time since stroke onset varied with studies including participants within one month (three trials: Blennerhassett 2004; English 2015; Outermans 2010), three months (three trials: Kim 2016a, Van de Port 2012; Verma 2011), six months (one trial: Holmgren 2010), one year (one trial: Harrington 2010), and more than one year post stroke (eight trials: Dean 2012; Moore 2015; Tang 2014; Dean 2000; Marigold 2005; Marsden 2010; Mudge 2009a; Pang 2005). One trial did not report the exact time since stroke (Song 2015). Only two studies collected objective measures of stroke severity, both of which used the National Institutes of Stroke Scale (Tang 2014; Verma 2011). For the majority of the other studies, stroke severity could be inferred as being mild to moderate, as their inclusion criteria for functional ability was only participants who were able to walk at least 5 m (Tang 2014) or 10 m independently, with or without a walking aid. Two studies included people living at home in the community with no reference to walking ability (Harrington 2010; Marsden 2010), and one included people in the moderate band of stroke severity according to score ranges on the Functional Independence Measure (FIM) (English 2015).

All studies investigated the effects of CCT (workstation-based, task-specific practise in a group with a ratio of staff to client of 1:3 or higher) with the aim of improving mobility in people post stroke. Two studies also explicitly aimed to improve cardiorespiratory fitness and included a target heart rate zone within their intervention (Outermans 2010; Tang 2014). Three studies combined CCT with education sessions (Harrington 2010; Holmgren 2010; Marsden 2010) and one combined CCT with mental imagery (Verma 2011). The length of therapy sessions, frequency (sessions per week), and duration of the intervention period varied somewhat between studies but were relatively homogeneous in terms of staffing and content - see Table 1 for a summary of all CCT formats. Five studies reported the percentage of therapy sessions attended and this ranged from 63% (Dean 2012) to 92% (Mudge 2009a), with Harrington 2010 reporting that 61% of participants attended at least 75% of therapy sessions. English 2015 reported the mean total amount of therapy time received per participant (37.3 hours) and Van de Port 2012 reported the total number and average duration of therapy sessions delivered to intervention participants (4461 sessions, mean 72 minutes' duration).

Twelve studies had a comparison group involving alternate 'other interventions', which was matched for length of sessions, frequency, and duration of intervention for eight studies. The description of the comparison 'other interventions' ranged from usual care (English 2015; Kim 2016a; Song 2015; Van de Port 2012; Verma 2011), CCT involving upper limb training only (Blennerhassett 2004; Dean 2000; Dean 2012; Pang 2005), non-specific exercises such as stretching (Marigold 2005; Moore 2015) or education/social groups (Mudge 2009a). Three studies compared CCT combined with education versus no therapy (Harrington 2010; Holmgren 2010; Marsden 2010). In two studies the comparison group also received mobility-related CCT but at a lower intensity (without a target heart rate) (Outermans 2010; Tang 2014).

All studies used a composite of measures related to mobility including tests of walking ability (gait speed and capacity), and balance (TUG, Berg Balance Scale (BBS), Step test). Some studies used measures of quality of life, upper limb function, balance self-efficacy, tests for impairment (strength, VO_2max, kinematic data), free-living walking ability (steps per day using an activity monitor), numbers of adverse events (falls during therapy), satisfaction, and length of stay. Only one study included measures of economic indicators (Harrington 2010). A total of 62 different outcome measures were reported in the included studies.

Excluded studies

We excluded the remaining studies for a variety of reasons including inappropriate methods, or interventions that were either not task-specific (that is to say the interventions addressed impairments not functional tasks) or not in a group (staff-to-client ratio was less than 1:3). See Characteristics of excluded studies for individual reasons for exclusions.

Risk of bias in included studies

Figure 2 summarises the trials together with risk of bias in the six domains, with the most likely risk in the area of selective reporting of outcome data, which was frequently rated as unclear because the majority of included studies did not publish a trial protocol or register their trials. Figure 3 shows the trials individually across the six domains. Three of the 17 trials demonstrated adequate control of risk across all six domains (Dean 2012; English 2015; Mudge 2009a).

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

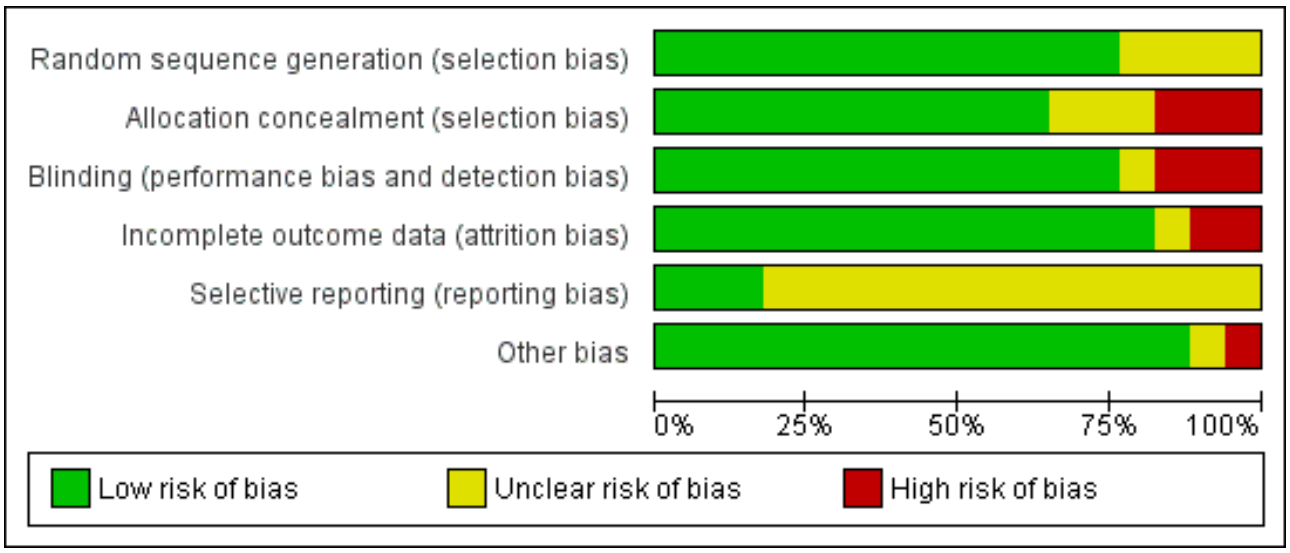
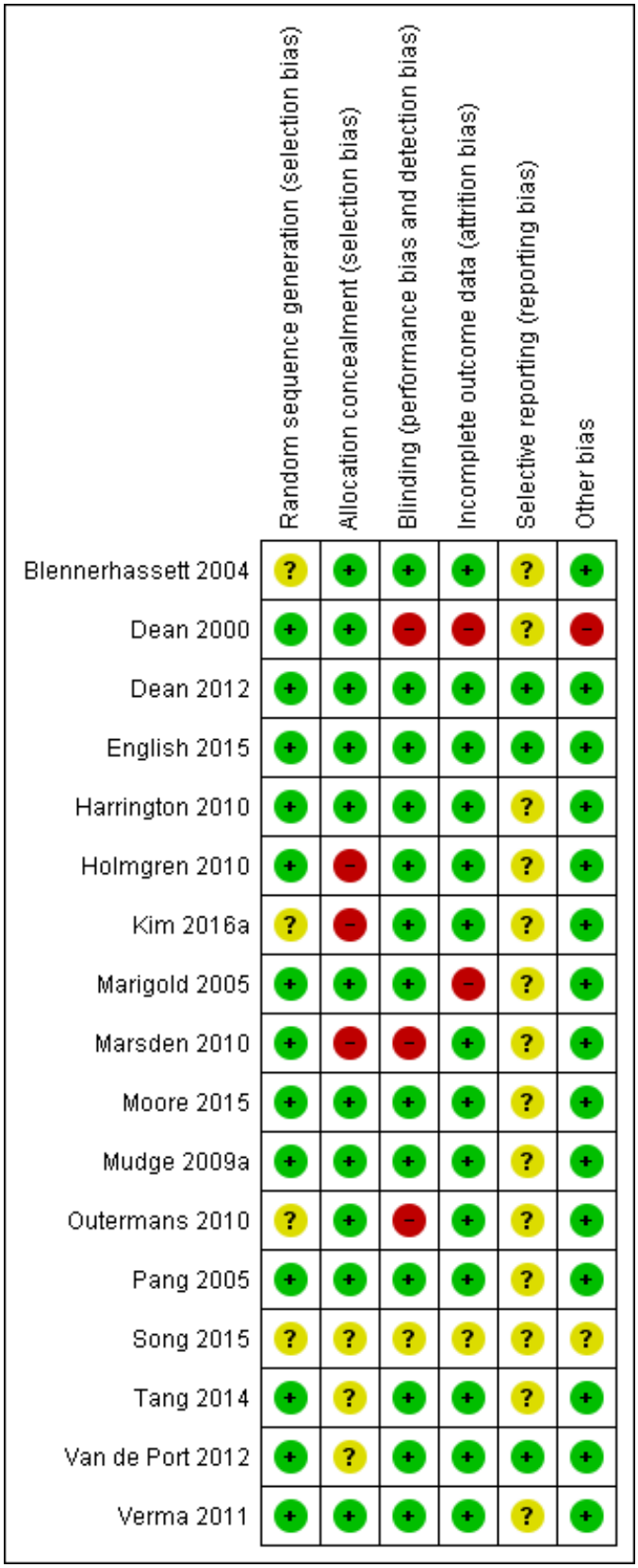


Figure 3. Methodological quality summary: review authors' judgements about each methodological quality item for each included study.



Allocation

Thirteen studies stated the allocation method for randomising, with the remaining four studies stating that random allocation occurred but not how (Blennerhassett 2004; Kim 2016a; Outermans 2010; Song 2015). Six studies either did not conceal or did not state whether or how allocation was concealed to the administrator of the randomisation process (Holmgren 2010; Kim 2016a; Marsden 2010; Song 2015; Tang 2014; Van de Port 2012).

Blinding

Four studies did not report blinding of assessors involved in the trial (Dean 2000; Marsden 2010; Outermans 2010; Song 2015).

Incomplete outcome data

Three studies did not adequately report and/or account for attrition across the trial groups (Dean 2000; Marigold 2005; Song 2015).

Selective reporting

Only three studies provided a reference to the trial registration or study protocol with all three studies demonstrating complete reporting (Dean 2012; English 2015; Van de Port 2012).

Other potential sources of bias

We noted other potential sources of bias, such as small numbers (Dean 2000), and cursory reporting across all aspects of trial conduct (Song 2015).

Effects of interventions

See: **Summary of findings for the main comparison** Circuit class therapy compared with other intervention for improving mobility

CCT versus 'other interventions'

Sufficient clinical homogeneity allowed us to pool study data, comparing CCT for mobility versus 'other intervention(s)'.

Primary outcome

Ten studies (835 participants, 64% of total sample) measured walking capacity using the 6mWT (Blennerhassett 2004; Dean 2000; Dean 2012; English 2015; Kim 2016a; Moore 2015; Mudge 2009a; Pang 2005; Van de Port 2012; Verma 2011). Meta-analysis demonstrated that overall CCT was superior to the comparison intervention (MD 60.86, 95% CI 44.55 to 77.17; I^2 = 27%, Analysis 1.1). Subgroup analysis between trials with participants who were early versus late after stroke onset showed a greater mean difference (improvement) for the later group but failed to reach a significant difference between these subgroups (P = 0.14).

Using the GRADE criteria based on the number of participants, the significant effect and relatively narrow CIs, we applied an overall rating of 'moderate', however we downgraded due to uncertain risk of bias across several studies.

Secondary outcomes

Eight studies (744 participants, 57% of total sample) measured gait speed (Dean 2000; Dean 2012; English 2015; Moore 2015; Mudge 2009a; Song 2015; Van de Port 2012; Verma 2011), with meta-analysis showing a difference between the two groups that reached significance in favour of CCT (MD 0.15, 95% CI 0.10 to 0.19; I^2 = 14%, Analysis 1.2). Using the GRADE criteria based on the number of participants, the significant effect and relatively narrow CIs, we applied an overall rating of 'moderate', however we downgraded due to uncertain risk of bias across several studies.

Two studies (50 participants) measured cadence in steps per minute and found a significant effect in favour of CCT (Song 2015; Verma 2011: MD 13.57, 95% CI 7.52 to 19.62; I^2 = 0%, Analysis 1.3).

Five studies (488 participants) used the TUG test to measure the ability to stand up, walk, and turn around, and meta-analysis showed a difference between the two groups that reached significance in favour of CCT ((Blennerhassett 2004; Dean 2000; Dean 2012; Marigold 2005; Van de Port 2012: MD -3.62, 95% CI -6.09 to -1.16; I^2 = 0%, Analysis 1.4). Two studies (296 participants) measured mobility using the Rivermead Mobility Index (Mudge 2009a; Van de Port 2012). The meta-analysis showed a significant effect in favour of CCT (MD 0.56, 95% CI 0.17 to 0.95; I^2 = 7%, Analysis 1.5). Three studies (469 participants) measured independence in walking using the Functional Ambulation Classification (English 2015; Van de Port 2012; Verma 2011) and found a significant effect in favour of CCT (OR 1.91, 95% CI 1.01 to 3.62; I^2 = 34%, Analysis 1.6).

Four studies (171 participants) applied the Berg Balance Scale with meta-analysis showing no significant between-group differences (Kim 2016a; Moore 2015; Marigold 2005; Pang 2005: MD 1.21, 95% CI -0.62 to 3.04; I^2 = 30%, Analysis 1.7). Three studies (190 participants) used the Step Test to measure balance with no significant between-group differences (Blennerhassett 2004; Dean 2000; Dean 2012: MD 0.98, 95% CI -0.40 to 2.37; I^2 = 21%, Analysis 1.8). Two studies (103 participants) measured balance self-efficacy using the Activities-specific Balance Confidence Scale (ABC) with meta-analysis showing a significant effect in favour of CCT ((Marigold 2005; Mudge 2009a: MD 7.76, 95% CI 0.66 to 14.87; I^2 = 0%, Analysis 1.9).

Two studies (437 participants) used the Stroke Impact Scale - physical sub-scale to measure self-reported physical ability (English 2015; Van de Port 2012). The meta-analysis demonstrated a favourable effect for CCT that just met significance (MD 2.91, 95% CI 0.00 to 5.82; I^2 = 0%, Analysis 1.10).

Two studies measured fitness using VO2 peak (Moore 2015; Pang 2005, 103 participants). A significant favourable effect was found for CCT participants (MD 2.81, 95% CI 0.90 to 4.72; I^2 = 0%, Analysis 1.11). Two studies (206 participants) included measures of average daily step counts and found significant effect in favour of CCT (Mudge 2009a; Dean 2012: MD 1325.66, 95% CI 411.09 to 2240.22; I^2 = 29%, Analysis 1.12).

Two trials (217 participants) measured length of stay (Blennerhassett 2004; English 2015). A shorter length of stay was reported for participants receiving CCT (MD -16.35, 95% CI -37.69 to 4.99; I^2 = 51%), but this was not significant when random effects were applied (given the high heterogeneity) (Analysis 1.13).

CCT + education versus no intervention

Sufficient clinical homogeneity allowed us to pool study data, comparing CCT + education versus no intervention. Two studies measured balance using the TUG (269 participants) with no significant between group differences found (Harrington 2010; Marsden 2010: MD 0.90, 95% CI -0.94 to 2.75; I^2 = 0%, Analysis 2.1). The same two studies measured carer burden using the Carer

Strain Index (Harrington 2010; Marsden 2010, 174 participants). The meta-analysis showed a negative effect of the intervention with higher Carer Strain Index (worse functioning) reported by carers of participants in the CCT + education group (MD 1.06, 95% CI 0.39 to 1.73; I^2 = 0%, Analysis 2.2).

CCT versus a different CCT

Two studies compared mobility-related CCT provided at high intensity (with target heart rate zones) versus the same exercises at low intensity (Outermans 2010; Tang 2014). The 6mWT was the only outcome in common between these trials, but due to the differences in the duration of the intervention there was insufficient clinical homogeneity to pool data (six months in Tang 2014 versus four weeks in Outermans 2010).

All comparisons

Eight studies (836 participants) reported monitoring adverse events including falls. Of these, four studies reported that there were no falls, and the other four reported between six falls (Pang 2005) and 55 falls (Van de Port 2012). There was a higher risk of falls in the CCT groups (risk difference 0.03, 95% CI -0.02, 0.08; I^2 = 60%) but this did not reach significance (Analysis 3.1).

Sensitivity analyses: primary outcome

We conducted a sensitivity analysis based on the size of the trial, considering large trials to be those with 100 or more participants (Dean 2012; English 2015; Harrington 2010; Van de Port 2012) and small trials to be those with fewer than 100 participants (Blennerhassett 2004; Dean 2000; Holmgren 2010; Kim 2016a; Marigold 2005; Marsden 2010; Moore 2015; Mudge 2009a; Outermans 2010; Pang 2005; Song 2015; Tang 2014; Verma 2011). The size of effect for the 6mWT was smaller but still significant when pooling only data from large trials (MD 46.31, 95% CI 22.90 to 69.72; participants = 588; studies = 3; I^2 = 11%) compared with small trials (MD 74.59, 95% CI 51.85 to 97.32; participants = 247; studies = 7; I^2 = 17%).

We also conducted a sensitivity analysis based on risk of bias where the three studies with no/low assessed risk of bias in the six domains confirmed a positive effect in favour of CCT for the 6mWT (Dean 2012; English 2015; Mudge 2009a: MD 46.32, 95% CI 17.40 to 75.24; I^2 = 38%) (Analysis 1.14).

DISCUSSION

Summary of main results

The primary aim of this review was to investigate the effectiveness of group CCT for improving mobility after stroke. For our primary outcome measure of gait capacity, we found CCT to be superior to other interventions for improving the distance walked on the 6mWT. The minimal clinically-meaningful improvement on the 6mWT has been estimated at 34.4 m for people later after stroke (Eng 2004) and 61 m for people early after stroke (Perera 2006). Thus, we can be confident that the mean improvement found in the meta-analysis of 60.86 m represents a real and applicable clinical change. The positive finding for the 6mWT is of functional relevance as it has been shown to be a stronger predictor of the community walking ability than measures of walking speed (Fulk 2010; Mudge 2009b; Rand 2009), which may overestimate community ambulatory ability (Taylor 2006). Furthermore, the 6mWT has been shown to correlate significantly with quality of life after stroke (Muren 2008). We also confirmed that the positive effects were present for people both early and late after stroke suggesting potential for improvement does not necessarily decline. A further positive feature of the primary outcome analyses was that heterogeneity was low. However, we downgraded the GRADE designation to 'moderate' because of the potential for risk of bias in some included studies.

We also found a small favourable effect of CCT in regards to improvements in walking speed, with the magnitude of the between-group difference (0.15 m per second) being greater than the estimated smallest worthwhile effect of 0.06 m per second (Perera 2006). Perera 2006 suggest that a difference of greater than 0.14 m per second represents a substantial meaningful change for people after stroke. Thus, we can be confident that our results represent real clinical change. Our results suggest that CCT as an intervention has a positive effect on improving independence in walking, with the odds of being fully independent in walking (Functional Ambulation Scale score of 5) after the intervention being significantly greater for intervention participants compared with people allocated to the control intervention.

The evidence for the effectiveness of CCT in improving walking ability after stroke can be considered robust as it is consistently positive across a range of clinic-based walking measures (6mWT, walking speed, Functional Ambulation Classification) and self-reported physical function (Stroke Impact Scale - Physical, Rivermead Mobiity Index). The intervention across all studies included a strong emphasis on continuous walking practice. Therefore, the positive results are in line with evidence for intensity and task-specificity of training, that is to say 'what is trained is what is gained' (Verbeek 2014).

There is some evidence that improvements in walking capacity and ability gained through CCT may also translate into behaviour change. In this updated review, two studies included measures of daily step counts, measured using either a pedometer (Dean 2012) or an ankle-worn accelerometer (Mudge 2009a). Both trials found that participants who received CCT increased their daily step count to a significantly greater degree than control participants. This is important, as lack of adequate physical activity is linked to increased all-cause morbidity and mortality (Lollgen 2009) and cardiovascular disease-specific morbidity and mortality (Thompson 2003), as well as increased risk of stroke (Feigin 2014; McDonnell 2013).

Importantly, CCT may also be an effective method of training for improving cardiorespiratory fitness for people later after stroke. Many studies (Marsden 2013; Marsden 2016; Smith 2012) have reported fitness levels of stroke survivors at less than the minimum requirement for activities of daily living in older adults, that is, 15 mL/kg/min to 18 mL/kg/min (Shephard 2009). An improvement in fitness in the order of magnitude found in our meta-analysis (2.8 mL/kg/min) is similar to that conferred by exercise interventions with an aerobic component (Marsden 2013). This amount is clinically important as it can improve the exercise reserve of stroke survivors (Ivey 2006) and has the potential to reduce the risk of death (Kodama 2009).

The effectiveness of CCT for improving postural control is less clear. We found significant between-group differences in favour of CCT for the Activities-specific Balance Confidence scale and the

TUG that exceeded the minimal detectable difference on these measures (Flansbjer 2005; Salbach 2006). However, between-group differences were non-significant for the step test, and too small to be clinically worthwhile on the Berg Balance Scale: MD of 1.36 points compared with minimal detectable change of 6.9 points early after stroke (Stevenson 2001), and 4.13 points later after stroke (Flansbjer 2012).

There is some suggestion that providing CCT to people receiving in-hospital rehabilitation after stroke may reduce length of hospital stay with a mean between-group difference of 16.35 days. However, the heterogeneity in the study results was higher (I^2 = 51%) and the difference just failed to reach significance using random effects in the analysis. There are many factors that influence length of hospital stay. A recent individual patient meta-analysis was conducted where data were pooled from two large multicentre trials investigating the effect of additional weekend therapy for people with stroke. The meta-analysis identified a range of factors that significantly contributed to length of rehabilitation hospital stay, including age and degree of disability at admission (English 2016). Interestingly, this paper also reported considerable variability in length of stay between individual hospital sites, highlighting the complexity of factors that influence how long people with stroke spend in inpatient rehabilitation. However, a secondary analysis of data from the CIRCIT trial (English 2015) found that when controlling for other influencing factors, receiving CCT as the sole method of physiotherapy service delivery (as compared to usual care physiotherapy) was an independent predictor of a shorter length of stay, in the order of -11.6 days (95% CI -21.3 to -1.9, P = 0.019) (Abstracts Asian Pacific Stroke Congress p6). Reducing length of stay has the potential for significant savings to the healthcare system, but we currently lack high-quality economic data to establish the cost effectiveness of such an approach.

With regards to adverse events, there were more falls (albeit not statistically different) reported among participants receiving CCT compared with other interventions. Any intervention aimed at improving mobility and balance after stroke carries an inherent risk of causing falls because it is necessary for participants to undertake activities at the limits of their abilities for the interventions to be effective. The greater falls rate in the intervention group is perhaps not surprising considering that the control group was either undertaking interventions that did not expose the participants to an increased risk of falls; for example, seated upper extremity exercise programmes (Blennerhassett 2004; Dean 2000; Pang 2005), stretching (Marigold 2005; Moore 2015), education (Holmgren 2010; Mudge 2009a), or had significantly less risk exposure because they spent significantly less time engaged in physical therapy sessions (English 2015). Nevertheless, it would be pertinent for future studies to more closely examine the link between CCT and falls in therapy.

Carer burden was reported as increased in two studies comparing CCT plus education against no intervention (Harrington 2010; Marsden 2010). It is unknown how the burden was generated and whether it was simply because of receipt of an intervention per se - this requires clarification in future studies.

Based on the results of the two available trials, there is currently no evidence for superior effectiveness of CCT when combined with education. Similarly, there is insufficient evidence for the relative effectiveness of CCT delivered at higher versus lower intensity (based on heart rate targets).

Overall completeness and applicability of evidence

The content of the intervention provided was similar across all studies with many of the same exercises and activities included (see Characteristics of included studies and Table 1). The majority (11) of the trials were conducted with participants later after stroke (more than one year), compared with earlier after stroke (less than one year, six trials) and whilst our subgroup analyses failed to show a significant difference in effect between the two time frames, there was a larger improvement noted in the later group for several measures. The influence of time alone on recovery after stroke remains largely unknown, although it has been estimated to account for between 16% and 42% of improvements in function in the first six to 10 weeks after stroke (Kwakkel 2004). This may mask any potential benefits of CCT over and above usual care in studies conducted with people earlier after stroke.

There were insufficient data available to examine the impact of CCT on sensorimotor impairment after stroke. No studies included measures of movement kinematics or stroke recovery biomarkers such as imaging. Therefore, we cannot determine the degree to which improvements in mobility measures are related to recovery of motor function, specifically 'true neurological recovery' (Levin 2009) versus compensation and overcoming deconditioning.

This updated review included four trials with sample sizes greater than 100 participants. When we pooled data from only these trials, the magnitude of effect for CCT was smaller, but remained statistically significant for the 6mWT. Smaller trials tend to over-estimate treatment effects (Pereira 2012). The implications of population heterogeneity across large and small trials need to be considered. Furthermore, our 6mWT results were upheld after a sensitivity analysis for trials with low versus unclear/high risk of bias.

The ability to pool data across trials was somewhat limited by the diversity in outcome measures used. Across the 17 included trials, a total of 62 different outcome measures were used. Lack of commonality in outcome measures is a major issue hampering the progress of stroke rehabilitation and recovery research. An analysis of 38 trials in the Virtual International Stroke Archives in 2012 found at least 44 reported outcome measures, with age being the only common metric across trials (Ali 2013). A group of international experts is currently working on addressing this issue with consensus statements being produced as a result (Bernhardt 2016).

Quality of the evidence

The trials were of varying levels of assessed risk of bias. Most commonly, failure to report one or two domains led to a greater overall risk and it remains to be seen if standards of trial conduct and reporting improve in the future. We cannot differentiate between failure to report versus failure to control the risk and this is a potential source of bias in the review process. Hence we downgraded all GRADE determinations as a result of this uncertainty. Three studies achieved 'low' risk ratings in all six domains, confirming that stroke rehabilitation studies can be conducted and reported in an acceptable manner.

Potential biases in the review process

Potential biases in the review process need to be considered in that the three review authors are stroke rehabilitation trialists and take a pragmatic stand on trial design. For example, we did not assess trials as having a risk of bias where the therapist or the participants were not blinded, as we did not consider this possible in these kinds of clinical trials (other than to maintain the participant naive as to which arm of the trial was of interest to the researchers). The definition of CCT was relatively prescriptive and it may be that studies using an alternate circuit format were not included. For example, Kim 2016b compared group CCT with individualised CCT - however their definition of individualised CCT met the criteria for this review's group CCT, thus not offering a useful comparator. It is important that studies such as this are considered in future, as they may help ascertain which aspects of CCT are effective.

Agreements and disagreements with other studies or reviews

This updated review strengthens the findings of our previous review and the systematic review of Wevers 2009, that CCT is an effective intervention for improving walking ability in people after stroke. The updated findings highlight that the benefit of CCT is reported regardless of time after stroke. This update also provides new evidence that CCT may be an effective method of improving cardiorespiratory fitness and increased daily physical activity (step counts).

AUTHORS' CONCLUSIONS

Implications for practice

Based on the existing moderate evidence, circuit class therapy (CCT) is effective in improving walking ability in people after stroke, and this effect was found when delivered in early and late periods after stroke. There is insufficient evidence to determine whether providing physiotherapy using the CCT format for people receiving inpatient rehabilitation may reduce length of hospital stay. Relative to other interventions, there is insufficient evidence to determine whether CCT was associated with an increased risk of falls Therapists should use strategies to reduce the risk of falls while trying to maintain the integrity of the intervention.

Implications for research

The evidence is becoming clearer and more consistent for the effectiveness of CCT for improving mobility in people after stroke who are able to walk independently. It will be important in future trials to include different subgroups of people with stroke, as well as measurement of changes at the impairment level to help to determine the effect of CCT on true neurological recovery versus compensation. Other aspects of the mechanism of effect are also not clear and likely to be a combination of increased motivation, amount and intensity of practice, as well as the specificity of the practice. Mechanism pathways need further investigation. Further investigation is also needed into the mitigation of risk of falls and the potential strain on carers.

ACKNOWLEDGEMENTS

Anthea Worley and Debbie Booth for assisting with searches. Ashlee Dunn and Gary Crowfoot for assistance with data extraction and editing. Staff of the Cochrane Stroke Group.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Blennerhassett 2004

Methods	RCT

Blennerhassett 2004 *(Continued)*

	Mobility CCT versus upper limb CCT
Participants	30 participants (15 each group) receiving inpatient rehabilitation (mean of 43 days post-stroke), mean age 55.1 years, able to walk 10 m with close supervision with or without gait aids
Interventions	Intervention: mobility-related CCT, 10 5-minute workstations consisting of functional tasks including sit to stand, step ups, obstacle course walking, standing balance, stretching and strengthening exercises); 1 h/day, 5 days/week for 4 weeks Comparison: upper limb-related CCT, 10 5-minute workstations consisting of functional tasks to improve reach to grasp, hand eye co-ordination, stretching and strengthening exercises; 1 h/day, 5 days/week for 4 weeks Staff:participant ratio: 1:4 Both groups received additional CCT therapy in addition to usual care
Outcomes	6mWT, Step Test, TUG, LOS, MAS upper arm and hand items, JTHFT
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Card draw: unclear how cards were constructed
Allocation concealment (selection bias)	Low risk	Sealed, opaque envelopes, independent person
Blinding (performance bias and detection bias) All outcomes	Low risk	Assessor blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	100% data at 4 weeks
Selective reporting (reporting bias)	Unclear risk	No trial protocol
Other bias	Low risk	Adequate sample size

Dean 2000

Methods	RCT Mobility CCT versus upper limb CCT
Participants	9 participants (intervention = 5, comparison = 4), mean 1.3 years post-stroke, mean age 62.3 years, able to walk 10 m independently with or without gait aid
Interventions	Intervention: mobility-related CCT, 10 workstations functional tasks including seated reaching beyond arms' reach, sit to stand, stepping activities, heel lifts, standing balance, strengthening exercises, walking activities; 1 h, 3 times/week for 4 weeks Comparison: upper limb-related CCT, workstations consisting of upper limb tasks; 1 h, 3 times/week for 4 weeks

Dean 2000 *(Continued)*

	Staff:participant ratio: 1:6
Outcomes	6mWT, Step Test, TUG, gait speed, peak vertical ground reaction force through affected lower limb during sit-to-stand, laboratory measures of gait kinematics and kinetics
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation by lottery: "drawing two cards, one with subject's name and one with group allocation from two separate boxes"
Allocation concealment (selection bias)	Low risk	Cards drawn by a person independent of the study
Blinding (performance bias and detection bias) All outcomes	High risk	Clinical assessments, with exception of 6mWT, conducted by independent rater; however, this blinding may have been unmasked as the result of this observer inadvertently observing 1 training session
Incomplete outcome data (attrition bias) All outcomes	High risk	Missing data balanced across groups (1 in experimental and 2 in control) for transport or unrelated illness reasons, but no intention-to-treat analysis undertaken
Selective reporting (reporting bias)	Unclear risk	No trial protocol
Other bias	High risk	Very small sample size

Dean 2012

Methods	RCT Mobility CCT + home exercise programme versus upper limb CCT + home exercise programme
Participants	151 participants (intervention = 76, comparison = 75), mean 6.0 years post-stroke, mean age 67.1 years, able to walk 10 m independently with or without gait aid
Interventions	Intervention: mobility-related CCT, task-related training with progressive balance, strengthening, standing, walking and stair climbing exercises, home programme and advice to increase walking Comparison: upper-limb related CCT, task-related strength and co-ordination training, cognitive training, home programme and advice to increase use of upper limb and engage in more cognitive tasks Staff:participant ratio: not reported
Outcomes	6mWT, gait speed, TUG, 5 x sit-to-stand test, step test, timed single leg stance, co-ordinated stability test, maximal balance range, choice stepping reaction time, number falls in 12 months, falls risk score, knee extensor strength, Short Form-12, Adelaide Activity Profile, daily step counts
Notes	Adverse events and attendance at classes also reported

Risk of bias

Bias	Authors' judgement	Support for judgement

Dean 2012 *(Continued)*

Random sequence generation (selection bias)	Low risk	Randomisation was computer-generated prior to commencement of study
Allocation concealment (selection bias)	Low risk	Sealed, opaque envelopes
Blinding (performance bias and detection bias) All outcomes	Low risk	"The participants and therapists delivering the intervention could not be blinded to intervention group allocation." Apart from self-reported falls, "All other outcome measures were collected by an assessor who was blinded to group allocation." Participants asked not to reveal details of the programme to the assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	"Missing data for individual variables were imputed using regression, where possible." "Overall, missing data amounted to less than 10%." "Attendance records kept by the therapists indicated that only 6 participants (experimental = 1; control = 5) did not attend a single class." All reasons for loss to follow-up were reported
Selective reporting (reporting bias)	Low risk	Protocol available, and all the pre-specified outcomes were reported
Other bias	Low risk	No other sources of bias are evident

English 2015

Methods	RCT (3 arms) CCT (mobility and upper-limb) versus usual care (one-to-one therapy, 5 days/week) versus 7-day/week therapy (one-to-one). Only CCT and usual care arms included in this review
Participants	283 participants in whole trial (intervention = 93, comparison = 94), mean 29.8 days post-stroke, mean age 69.1 years, moderate disability (FIM total score of 40-80 OR motor score of 38-62)
Interventions	Intervention: physiotherapy service provided in twice daily 90-min CCT sessions, 5 days/week primarily focused on mobility. Included task-specific, individually progressed exercises focused on improving walking and standing activities Comparision: physiotherapy services based on usual care; primarily provided in individual, one-to-one therapy sessions 5 days/week Staff:participant ratio: between 1:3 and 1:6
Outcomes	6mWT, gait speed, functional ambulation classification, FIM, Stroke Impact Scale, Wolf Motor Function Test, Australian Quality of Life score
Notes	Data on therapy time provided and adverse events also available
Risk of bias	
Bias	**Authors' judgement** / **Support for judgement**

English 2015 *(Continued)*

Random sequence generation (selection bias)	Low risk	"A computer-generated randomization sequence was blocked to ensure equal numbers for each arm in each block of 15."
Allocation concealment (selection bias)	Low risk	"Randomisation was concealed by use of a central telephone service administered by staff not involved in the trial."
Blinding (performance bias and detection bias) All outcomes	Low risk	No mention of blinding participants or personnel. It would be unlikely that study participants and staff were blinded due to the nature of the trial. Unlikely to influence outcomes: "All outcomes were assessed by a trained assessor who was blinded to group allocation"
Incomplete outcome data (attrition bias) All outcomes	Low risk	"Analyses were first conducted with no imputation of missing data (reported)." The study found that when a multiple imputation was applied, it did not significantly influence the results Figure 1 shows a flow of participants including reasons for participants lost to follow-up. Usual care therapy = 6/94, 7 days/week = 8/96, usual care = 8/93
Selective reporting (reporting bias)	Low risk	Protocol available, and all the pre-specified outcomes were reported Cost-effectiveness sub-study to be reported in a different paper
Other bias	Low risk	No other sources of bias are evident

Harrington 2010

Methods	RCT Mobility CCT + education versus standard care and information sheet about support services
Participants	243 participants (intervention = 119, comparison = 124), minimum 12 months post, median 10.3 years post-stroke, mean age 70.5 years, living in the community and able to participate in groups
Interventions	Intervention: CCT with exercises adapted to ability aimed at improving balance, strength and endurance, plus home exercise programme, plus interactive self-management education sessions; 1 h exercise and 1 h of education twice a week for 8 weeks Comparison: standard care and information sheet with list of local exercise classes Duration and frequency: not reported Staff:participant ratio: 2:9
Outcomes	TUG, RMI, Functional Reach, Frenchay Activities Index, Hosptial Anxiety and Depression Scale, Subjective Impact of Physical and Social Outcome, WHO-QoL, Carer Strain Index
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"We used computer generated numbers in geographical blocks of 18 participants, with the unit of randomization being the patient."
Allocation concealment (selection bias)	Low risk	"Randomization was carried out centrally by an independent assistant who took no part in recruitment."

Harrington 2010 *(Continued)*

Blinding (performance bias and detection bias) All outcomes	Low risk	"Due to the nature of the intervention it was not possible to blind either the participants or the individuals involved in running the schemes…" "…outcome was assessed by a blinded assessor."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Analysis was undertaken on an intention-to-treat basis Figure 1 shows participant flow, with reasons for loss to follow-up available
Selective reporting (reporting bias)	Unclear risk	No study protocol
Other bias	Low risk	No other source of bias evident

Holmgren 2010

Methods	RCT Mobility CCT + education versus education only
Participants	34 participants (intervention = 15, comparison = 15), mean time since stroke 0.36 years, mean age 78.5 years, able to walk 10 m independently with or without gait aid (excluded if able to walk outdoors independently)
Interventions	Intervention: mobility-related CCT, focus on physical activity and functional performance and education about falls risk CCT duration not specified, 7 sessions a week for 5 weeks; education 1 h/week for 5 weeks Comparison: education about coping with hidden dysfunctions after stroke 1 h/week for 5 weeks Staff:participant ratio: not reported
Outcomes	Short-form 36, Geriatric Depression Scale
Notes	Secondary outcomes reported from original trial. Original trial not published suggesting possible publication bias

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	"…was conducted with a minimization software program, MiniM to avoid imbalances at baseline between the two groups."
Allocation concealment (selection bias)	High risk	Two main investigators responsible for randomisation
Blinding (performance bias and detection bias) All outcomes	Low risk	Single-blinded Participants were instructed not to reveal anything about group allocation. "All participants were blinded as for the content of the two different groups before randomization." No mention of blinding of staff, however unlikely due to nature of trial. Unlikely to influence outcomes.

Holmgren 2010 *(Continued)*

		"The nurses and physiotherapists who performed the clinical test assessments were blinded to group allocation."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Intention-to-treat analysis Figure 1 shows the participant flow including reasons for loss to follow-up All but 1 participant completed the 5-week intervention period 2 participants dropped out at follow-up due to health reasons
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Low risk	No other sources of bias evident

Kim 2016a

Methods	RCT Mobility CCT versus usual care therapy
Participants	20 participants (intervention = 10, comparison = 10), mean time since stroke 30.0 days, mean age 65.6, score 3 or 4 on Functional Ambulation Classification (able to walk with no more than 1 person assisting), less than 3 months post-stroke
Interventions	Intervention: mobility-related CCT, including trunk exercises, active sitting practice, sit-to-stand practice, standing and walking practice, aerobic exercise and strength training; 90 min/per day, 5 days/week for 4 weeks Comparison: usual care physiotherapy provided in 2 x 30-min sessions, 5 x per week for 4 weeks. Content based on neurodevelopmental approach and provided in one-to-one therapy sessions Staff:participant ratio: at least 2 participants to 1 therapist
Outcomes	6mWT, BBS, modified Barthel Index (Korean version), lower limb score of the Fugl-Meyer assessment
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Randomised via sealed envelope technique, random sequence generation not stated
Allocation concealment (selection bias)	High risk	No mention of allocation concealment
Blinding (performance bias and detection bias) All outcomes	Low risk	Assessors blinded to group allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data

Kim 2016a *(Continued)*

Selective reporting (reporting bias)	Unclear risk	No trial protocol
Other bias	Low risk	No other sources of bias identified

Marigold 2005

Methods	RCT Mobility-related CCT versus general balance class
Participants	59 participants (Group 1 = 28, Group 2 = 31), mean 3.7 years post-stroke, mean age 67.8 years, able to walk 10 m independently with or without gait aid
Interventions	Intervention: mobility-related CCT including walking, standing tasks focused on balance, sit to stand; 1-h sessions, 3 times/week for 10 weeks Group 2: stretching and slow weight shifting exercises; 1-h sessions, 3 times/week for 10 weeks Staff:participant ratio: not reported
Outcomes	BBS, TUG, ABC, NHP, standing postural reflexes using force platform, self-reported prospective falls diary
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated codes
Allocation concealment (selection bias)	Low risk	Person independent of the study
Blinding (performance bias and detection bias) All outcomes	Low risk	All assessors were blinded to group assignment, study design and purpose
Incomplete outcome data (attrition bias) All outcomes	High risk	Total of 11 lost before post-intervention testing, another 6 lost before follow-up No intention-to-treat analysis or imputation of missing data
Selective reporting (reporting bias)	Unclear risk	Protocol not published so unclear regarding whether all outcomes reported
Other bias	Low risk	Adequate sample size

Marsden 2010

Methods	RCT cross-over design Mobility-related CCT plus education versus wait list control

Marsden 2010 *(Continued)*

Participants	26 participants (Group 1 = 12, Group 2 = 14), mean 2.5 years post-stroke, mean age 71.7 years, clinical diagnosis of stroke
Interventions	Intervention: mobility-related CCT, 10 x 5-min workstations consisting of sit to stand, reaching, standing balance, walking figure 8, stationary bike; 1 h exercise and 1 h education, once a week for 7 weeks Comparison: wait list control Staff:participant ratio: 1:3
Outcomes	6mWT, TUG, Short-form 36 (physical), Carer Strain Index
Notes	Only first comparison (pre-cross over) included

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Toss of a coin by a team member
Allocation concealment (selection bias)	High risk	Team member responsible for allocation
Blinding (performance bias and detection bias) All outcomes	High risk	No mention of blinding of staff or participants, however unlikely due to nature of trial. Unlikely to influence outcomes Primary outcomes assessor blinded Secondary outcome assessors not blinded. Only secondary outcomes used in the meta-analysis
Incomplete outcome data (attrition bias) All outcomes	Low risk	Intention-to-treat. "… but no values were imputed for survivors or carers who did not attend an assessment session." Only 1 loss to follow-up (hospitalisation) for intervention group. Figure 1 flow diagram
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Low risk	No other sources of bias evident

Moore 2015

Methods	RCT Mobility CCT vs home stretching (matched duration)
Participants	40 participants (intervention = 20, comparison = 20), mean time since stroke 1.5 years, mean age 69 years, able to complete 6mWT with or without gait aid
Interventions	Intervention: mobility CCT based on FAME programme including warm-up, stretching, functional strengthening, balance, agility & fitness, cool down; 45-60 minutes, 3 times/week for 19 weeks Comparison: home stretching programme of matched duration; 45 to 60 minutes 3 times/week for 19 weeks

Moore 2015 *(Continued)*

	Staff:participant ratio: not reported
Outcomes	6mWT, gait speed, BBS, SIS (physical), VO2 peak, peak work rate, Addenbrook's Cognitive Examination (revised, ACE-r), blood cholesterol, 2-hour glucose, HOMA index, blood pressure, BMI, fat mass, brain physiology (cerebral blood flow)
Notes	Adverse events reported, not actual therapy time delivered

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"A computerized random number generator was used to allocate treatment by an independent administrator after screening."
Allocation concealment (selection bias)	Low risk	"… the administrator was telephoned for the next number in the sequence to enable participant randomisation."
Blinding (performance bias and detection bias) All outcomes	Low risk	Single-blind RCT No mention of blinding participants or personnel. It would be unlikely that study participants and staff were blinded due to the nature of the trial. Unlikely to influence outcomes Assessors were blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	States participants performed "… > 90% of outcome assessments and exercise sessions." Although these were not defined All participants completed the intervention, none lost to follow-up
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Low risk	No other sources of bias evident

Mudge 2009a

Methods	RCT Mobility-related CCT versus education or social groups
Participants	58 participants (Group 1 = 31, Group 2 = 27), mean 4.9 years post-stroke, mean age 69.1 years, able to walk 10 m independently with or without gait aid
Interventions	Intervention: mobility CCT, 15 2-min workstations including walking, standing balance and strengthening; 50-60 min 3 times/week for 4 weeks Comparison: 4 social and 4 educational sessions; duration not specified, twice a week for 4 weeks Staff:participant ratio: 3:9
Outcomes	Gait speed, 6mWT, RMI, ABC, steps per day using activity monitor, PADS
Notes	Repetitions and details about exercise intensity recorded each station

Risk of bias

Mudge 2009a *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated random numbers
Allocation concealment (selection bias)	Low risk	Person independent of the study matched the participants to the codes
Blinding (performance bias and detection bias) All outcomes	Low risk	Unmasking occurred for 3 out of 58 participants (5%)
Incomplete outcome data (attrition bias) All outcomes	Low risk	2 lost before randomisation, 3 withdrew before post-intervention assessment and a further 5 lost before follow-up assessment; losses balanced across groups Intention-to-treat analysis undertaken with imputation of missing data using carry forward method
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Low risk	Adequate sample size

Outermans 2010

Methods	RCT High-intensity, mobility-related CCT versus low-intensity, mobility-related CCT
Participants	44 participants (intervention = 23, comparison = 21), mean time since stroke 0.75 months, mean age 56.6, able to walk 10 m independently
Interventions	Intervention: high-intensity mobility CCT, workstations based on Dean 2000 with progressive target heart rate; 45-60 minutes, 3 times/week for 4 weeks in addition to 30 min/day usual care physiotherapy Comparison: low-intensity mobility CCT, not clear if same exercises were included, no progression of heart rate; 45-60 minutes, 3 times/week for 4 weeks in addition to 30 min/day usual care physiotherapy Staff:participant ratio: not reported
Outcomes	6mWT, gait speed, BBS, functional reach
Notes	Adverse events, duration (number of days) of training

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Reported as "randomly generated" but description of how was not presented
Allocation concealment (selection bias)	Low risk	"Allocation was performed by drawing randomly generated lots enclosed in opaque envelopes."
Blinding (performance bias and detection bias)	High risk	"All clinical assessments were conducted by one assessor, who was not blinded for allocation. To minimize bias the assessor was not present at the group

Outermans 2010 *(Continued)*

All outcomes		training at any time. Also previous assessments were not available during post-test assessment and all instructions were standardized."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Intention-to-treat. "Missing values were imputed using the assumption of a worst-case scenario in which the baseline value was carried forward." Reasons for loss to follow-up are available: 6 lost in intervention group, 7 in control group
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Low risk	No other sources of bias evident

Pang 2005

Methods	RCT Mobility CCT versus upper limb CCT
Participants	63 participants (Group 1 = 32, Group 2 = 31), mean 5.1 years post-stroke, mean age 65.3 years, able to walk 10 m independently with or without gait aids
Interventions	Intervention: mobility-related CCT based on FAME programme including warm-up, stretching, functional strengthening, balance, agility & fitness, cool down including target heart rate; 1-h session, 3 times/week for 19 weeks Comparison: upper-limb-related CCT including strengthening, range of motion, functional reach and manipulation tasks; 1-h session, 3 times/week for 19 weeks Staff:participant ratio: not reported
Outcomes	6mWT, BBS, VO_2max, knee extension strength (dynamometer), PASIPD, proximal femur BMD
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Drawing ballots
Allocation concealment (selection bias)	Low risk	Ballots drawn by person not involved with enrolment, screening, or outcome assessments
Blinding (performance bias and detection bias) All outcomes	Low risk	Research personnel who performed outcome assessments were blinded to group assignment
Incomplete outcome data (attrition bias) All outcomes	Low risk	Similar small amount of missing data across groups Missing data imputed from baseline values and intention-to-treat analysis used
Selective reporting (reporting bias)	Unclear risk	This study was reported in at least 3 separate papers all including different outcome measures
Other bias	Low risk	Adequate sample size

Song 2015

Methods	RCT Mobility CCT vs mobility CCT individually provided vs conventional therapy
Participants	30 participants (intervention = 11, comparison (individual) = 10, comparison (conventional therapy) = 9, more than 6 months post-stroke (mean and upper range not given), mean age 56.2, able to walk 10 m without assistance
Interventions	Intervention: mobility CCT, provided in circuit Comparison (individual): mobility exercises, provided one-to-one Comparison (conventional therapy): not described 30 min/day, 3 times/week for 4 weeks Inpatient rehabilitation Staff:participant ratio: not specified
Outcomes	Gait speed, cadence, self-esteem scale, motivation of rehabilitation, relationship change scale
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Insufficient information
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Unclear risk	Study failed to report any of the above points. Only small sample sizes (n = 9, n = 10, n = 11). Participant assignment was unclear: "Twelve patients were excluded due to health problems, so subjects were randomly assigned to …"

Tang 2014

Methods	RCT Mobility CCT (with aerobic exercise component) vs balance and stretching exercises without aerobic stimulus

Tang 2014 *(Continued)*

Participants	50 participants (intervention = 25, comparison = 25), mean 4.2 years post-stroke, mean 66.4 years, able to walk 5 m independently with or without gait aids
Interventions	Intervention: aerobic training with target progressive heart rate using brisk walking, cycling, step ups, sit to stands Comparison: balance and flexibility non-aerobic, including balance exercise progressed to be challenging 60-min sessions 3 times/week for 6 months Staff:participant ratio: 3:12
Outcomes	6mWT, VO_2 peak, arterial stiffness, cardiac function, cholesterol, triglycerides, fasting glucose
Notes	Adverse events and adherence to class attendance reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"… performed the randomisation using a computer-generated 1:1 allocation sequence and permuted block sizes of 2 or 4."
Allocation concealment (selection bias)	Unclear risk	States "concealed allocation" with no description
Blinding (performance bias and detection bias) All outcomes	Low risk	Single-blinded trial. Unlikely to influence outcomes "Blinded outcome assessors were used."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Intention-to-treat analysis Dropouts described, with only 3 from 1 group and none from the other. Reasons unrelated to the programme
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Low risk	No other sources of bias evident

Van de Port 2012

Methods	RCT Mobility CCT versus conventional (one-to-one) therapy
Participants	250 participants (intervention = 126, comparison = 124), mean 3.2 months post-stroke, mean age 57 years able to walk 10 m independently with or without walking aid, discharged from inpatient therapy
Interventions	Intervention: mobility related CCT, 8 x 3-min workstations activities designed to improve walking competency Comparison: individual (one-to-one) conventional therapy according to Dutch Guidelines 90 min twice a week for 12 weeks

Van de Port 2012 *(Continued)*

	Staff:participant ratio: 1:1.8
Outcomes	6mWT, gait speed, Functional Ambulation Classification, modified stairs test, TUG, timed balance test, RMI, Nottingham Extended Activities of Daily Living, Stroke Impact Scale (mobility), Fatigue Severity Scale, Falls Efficacy Scale, Hospital Anxiety and Depression Scale, motricity index (arm and leg)
Notes	Adverse events and actual therapy time delivered (in minutes) reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"….and randomisation took place using an online minimization procedure."
Allocation concealment (selection bias)	Unclear risk	The randomisation scheme was developed and held by an offsite company that provided the online randomisation program. When participants were recruited, members of research team would be notified of group allocation by text message
Blinding (performance bias and detection bias) All outcomes	Low risk	Single-blinded trial. Unlikely to influence outcomes "Three trained RAs who were blinded to treatment allocation, measured all outcomes before randomisation …"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Used last values carried forward for intention-to-treat analysis "Of the 250 included patients, one patient in the circuit training group and seven in the usual care group were excluded from the analysis."
Selective reporting (reporting bias)	Low risk	Protocol available Cumulative Illness Rating Scale not used in trial paper EuroQoL not used in trial paper Cost benefits not analysed in this paper Slightly different data analysis
Other bias	Low risk	No other sources of bias evident

Verma 2011

Methods	RCT Mobility CCT plus mental imagery vs conventional therapy (based on Bobath techniques)
Participants	30 participants (intervention = 15, comparison = 15), mean 1.5 years post-stroke (lower range from 3 months), mean age 54.2 years, Functional Ambulation Classification 2 or above (i.e. able to walk with assistance of 1 person)
Interventions	Intervention: mobility CCT, workstations including balance, stair walking, turning, transfers, and speed walking plus mental imagery Comparison: conventional lower limb therapy based on Bobath techniques 40-min sessions, 7 days/week for 2 weeks

Verma 2011 *(Continued)*

	Inpatient and outpatient sessions Staff:participant ratio: 1:4
Outcomes	6mWT, gait speed, Functional Ambulation Classification, Rivermead Visual Gait Assessment, cadence, step length asymmetry, Barthel Index
Notes	Adverse events

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	" … using computer generated random numbers." "A resident physician at the study site conducted the random-number program." Resident was blinded to the protocol and was not involved in the study
Allocation concealment (selection bias)	Low risk	"The intervention assignments were enclosed in sealed envelopes, which were opaque and sequentially numbered."
Blinding (performance bias and detection bias) All outcomes	Low risk	"The subjects were blinded for intervention of interest." Personnel delivering the intervention would likely not be blinded due to the nature of the program, however unlikely to influence outcomes "… study was an assessor-blinded RCT."
Incomplete outcome data (attrition bias) All outcomes	Low risk	"An intention-to-treat analysis was used with the last observation carried forward for the missing data." "Due to a second stroke, one of the subjects in the experimental group was lost for a follow-up assessment."
Selective reporting (reporting bias)	Unclear risk	No protocol available
Other bias	Low risk	No other sources of bias evident

6mWT: 6 Minute Walk Test
ABC: Activities-specific Balance and Confidence Scale
BBS: Berg Balance Scale
BMD: bone mineral density
CCT: circuit class therapy
FIM: Functional Independence Measure
ILAS: Iowa Level of Assistance Scale
JTHFT: Jebsen Taylor Hand Function Test
LOS: length of hospital stay
MAS: Motor Assessment Scale
NHP: Nottingham Health Profile
PADS: Physical Activity and Disability Scale
PASIPD: Physical Acitivity Scale for Individuals with Physical Disabilities
RCT: randomised controlled trial
RMI: Rivermead Mobility Index
TUG: Timed Up and Go
VO_2max: maximum oxygen volume

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Altin 2009	Intervention: not group format
Arya 2012	Intervention: not group format Aim: not to improve mobility
Boss 2014	Intervention: not group format, not repetitive practice Aim: not to improve mobility
Bustamante Valles 2016	Intervention: CCT group used robotic/technology-assisted stations not task-specific training
Chu 2004	Intervention: not task-specific training
Dickstein 2014	Intervention: not group format, not repetitive practice Aim: not to improve mobility
English 2007	Study design: pseudo randomised
English 2014	Aim: not to improve mobility
Faulkner 2014	Study design: not stroke (TIA)
Kim 2010	Intervention: not group format, no repetitive practice
Kim 2012	Intervention: not group format
Kim 2014	Intervention: not group format, no repetitive practice
Kim 2016b	Intervention: compared group CCT with individualised CCT. However individualised CCT fits definition of standard CCT. Therefore no useful comparison for this review.
Kowalczewski 2007	Intervention: not group format
Langhammer 2008	Intervention: not group format, not task-specific, not circuit
Lee 2012	Intervention: not repetitive practice Aim: not to improve mobility
Lee 2015	Aim: not to improve mobility
McDonnell 2014	Intervention: not repetitive practice Aim: not to improve mobility
Mead 2007	Intervention: not task-specific
Olney 2006	Intervention: not task-specific
Park 2016	Intervention: not group format
Puckree 2014	Intervention: not group format
Pyöriä 2007	Intervention: not group format

Study	Reason for exclusion
Quaney 2009	Intervention: not group format, not repetitive practice Aim: not to improve mobility
Rimmer 2000	Intervention: not task-specific
Saeys 2012	Intervention: not group format, not repetitive practice Aim: not to improve mobility
Salbach 2004	Intervention: not group format
Scianni 2010	Intervention: not group format
Sherrington 2008	Intervention: not task-specific
Shin 2011	Study design: not group format
Sullivan 2007	Intervention: not circuit format
Sunnerhagen 2007	Intervention: not task-specific
Tanne 2008	Intervention: not task-specific
Teixeira-Salmela 1999	Intervention: not task-specific
Yang 2006	Intervention: not group format

CCT: circuit class therapy

Characteristics of studies awaiting assessment *[ordered by study ID]*

Mota 2011

Methods	Experimental design
Participants	Victims of stroke
Interventions	Physiotherapy intervention using aerobic exercises
Outcomes	Gait parameters
Notes	Not in English

Scholten 2014

Methods	Possibly a systematic review with 22 RCTs
Participants	Unknown
Interventions	Fitness training
Outcomes	Physical fitness

Scholten 2014 *(Continued)*

Notes	Not in English

Characteristics of ongoing studies *[ordered by study ID]*

Floel 2014

Trial name or title	PHYS-STROKE
Methods	Phase III RCT
Participants	215 adults with moderate to severe limitations of walking and ADLs 5-45 days after stroke
Interventions	Physical fitness training plus standard rehabilitation; control relaxation sessions plus standard rehabilitation
Outcomes	Gait speed, Barthel Index, QoL, sleep, mood, cognition, arm function, cardiovascular factors.
Starting date	October 2013
Contact information	Correspondence: agnes.floeel@charite.de
Notes	

Lawal 2015

Trial name or title	CCT in Nigeria
Methods	Four-arm RCT
Participants	68 stroke survivors, community dwelling
Interventions	CCT of three different durations (60 min, 90 min, 120 min) versus usual care
Outcomes	Measures of impairment, activity and participation
Starting date	2014
Contact information	Correspondence: isalawal30@yahoo.com
Notes	

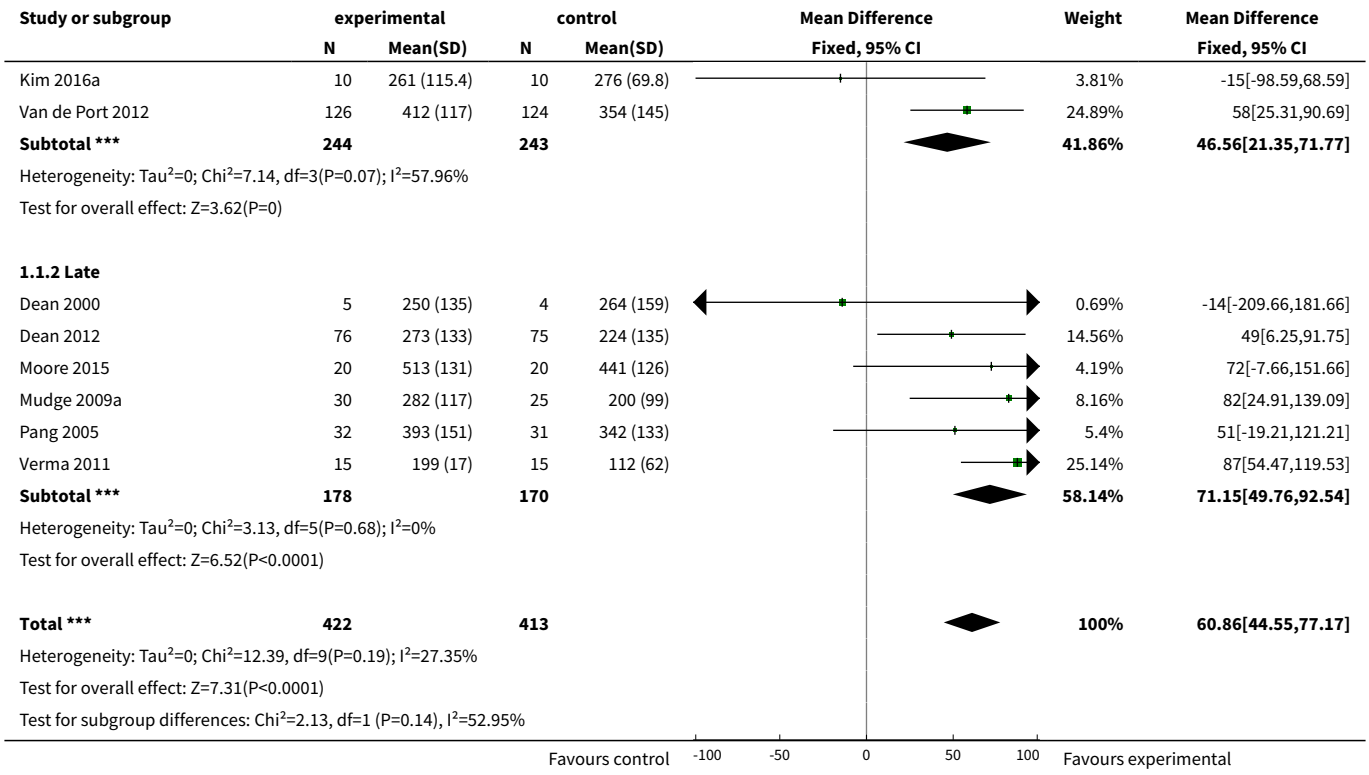
DATA AND ANALYSES

Comparison 1. Circuit class therapy versus other

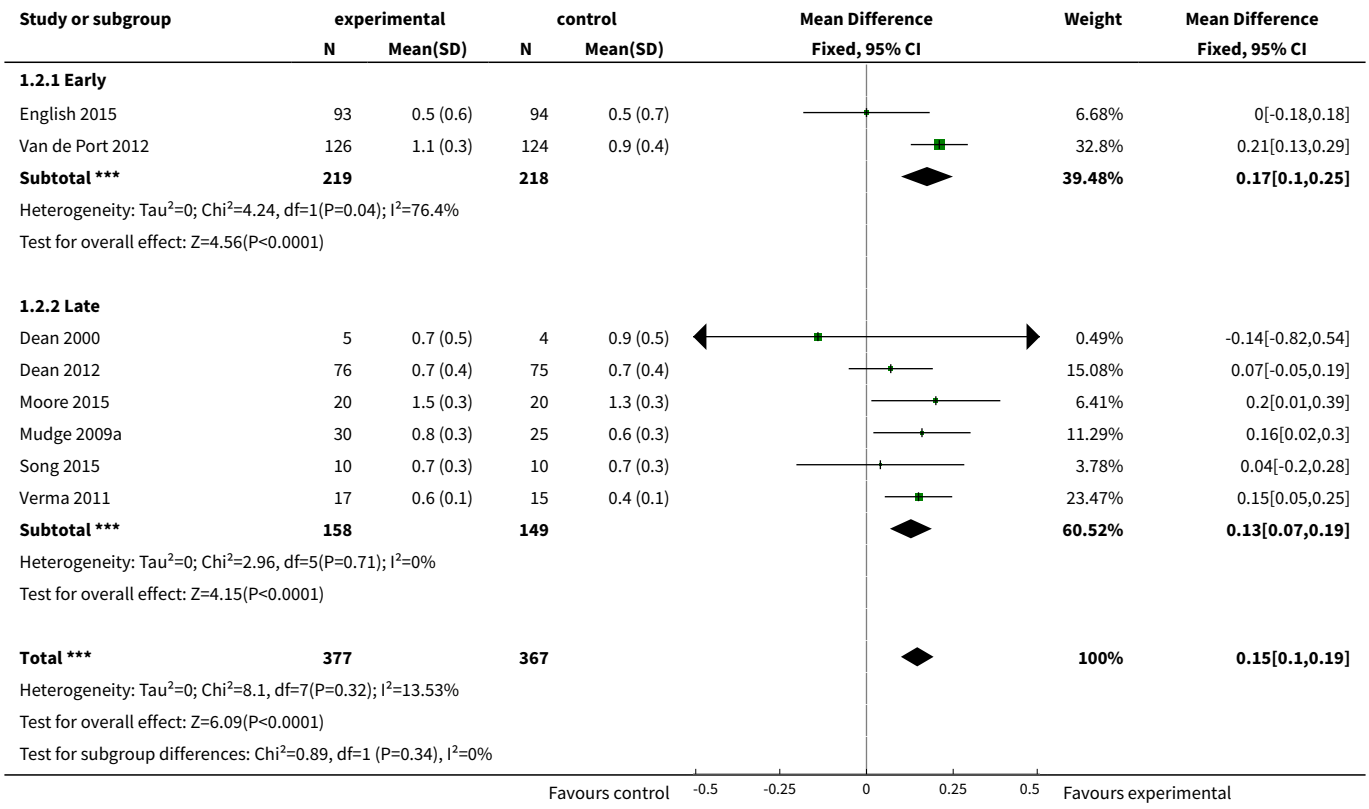
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 6mWT early and late	10	835	Mean Difference (IV, Fixed, 95% CI)	60.86 [44.55, 77.17]
1.1 Early	4	487	Mean Difference (IV, Fixed, 95% CI)	46.56 [21.35, 71.77]
1.2 Late	6	348	Mean Difference (IV, Fixed, 95% CI)	71.15 [49.76, 92.54]
2 Gait speed early and late	8	744	Mean Difference (IV, Fixed, 95% CI)	0.15 [0.10, 0.19]
2.1 Early	2	437	Mean Difference (IV, Fixed, 95% CI)	0.17 [0.10, 0.25]
2.2 Late	6	307	Mean Difference (IV, Fixed, 95% CI)	0.13 [0.07, 0.19]
3 Cadence	2	50	Mean Difference (IV, Random, 95% CI)	13.57 [7.52, 19.62]
4 Timed Up and Go	5	488	Mean Difference (IV, Fixed, 95% CI)	-3.62 [-6.09, -1.16]
5 Rivermead Mobility Index	2	296	Mean Difference (IV, Fixed, 95% CI)	0.56 [0.17, 0.95]
6 Functional Ambulation Classification	3	469	Odds Ratio (M-H, Random, 95% CI)	1.91 [1.01, 3.60]
7 Berg Balance Scale	4	171	Mean Difference (IV, Random, 95% CI)	1.21 [-0.62, 3.04]
8 Step Test	3	190	Mean Difference (IV, Fixed, 95% CI)	0.98 [-0.40, 2.37]
9 Activities-specific Balance Confidence Scale	2	103	Mean Difference (IV, Fixed, 95% CI)	7.76 [0.66, 14.87]
10 Stroke Impact Scale (physical)	2	437	Mean Difference (IV, Random, 95% CI)	2.91 [0.00, 5.82]
11 VO2 peak	2	103	Mean Difference (IV, Fixed, 95% CI)	2.81 [0.90, 4.72]
12 Steps per day	2	206	Mean Difference (IV, Fixed, 95% CI)	1325.66 [411.09, 2240.22]
13 Length of stay	2	217	Mean Difference (IV, Random, 95% CI)	-16.35 [-37.69, 4.99]
14 Sensitivity: 6mWT	3	393	Mean Difference (IV, Fixed, 95% CI)	46.32 [17.40, 75.24]

Analysis 1.1. Comparison 1 Circuit class therapy versus other, Outcome 1 6mWT early and late.

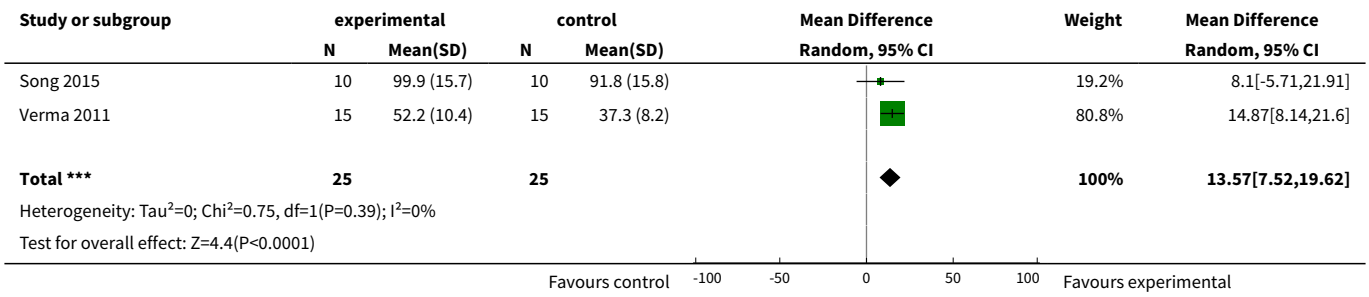
Study or subgroup	experimental N	experimental Mean(SD)	control N	control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
1.1.1 Early							
Blennerhassett 2004	15	404 (101)	15	288 (124)		4.06%	116[35.07,196.93]
English 2015	93	116 (179)	94	106 (198)		9.09%	10[-44.09,64.09]



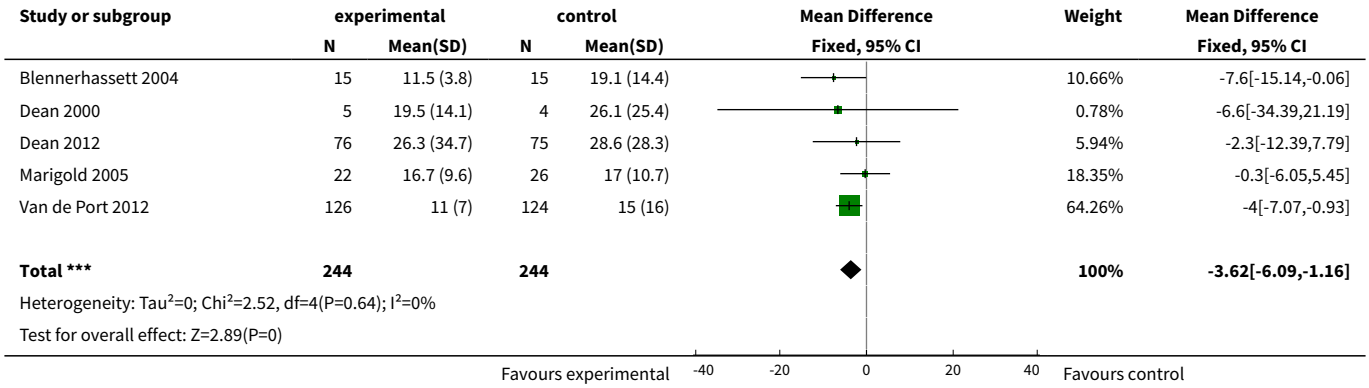
Analysis 1.2. Comparison 1 Circuit class therapy versus other, Outcome 2 Gait speed early and late.



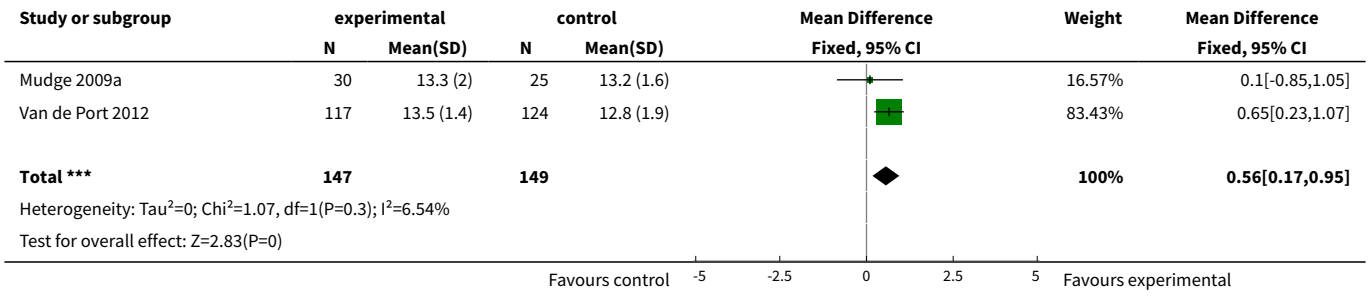
Analysis 1.3. Comparison 1 Circuit class therapy versus other, Outcome 3 Cadence.



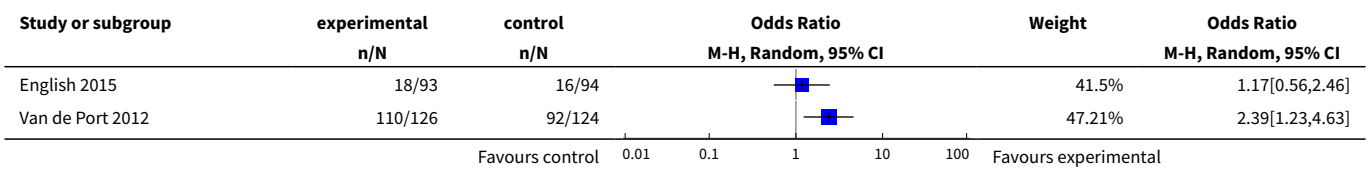
Analysis 1.4. Comparison 1 Circuit class therapy versus other, Outcome 4 Timed Up and Go.

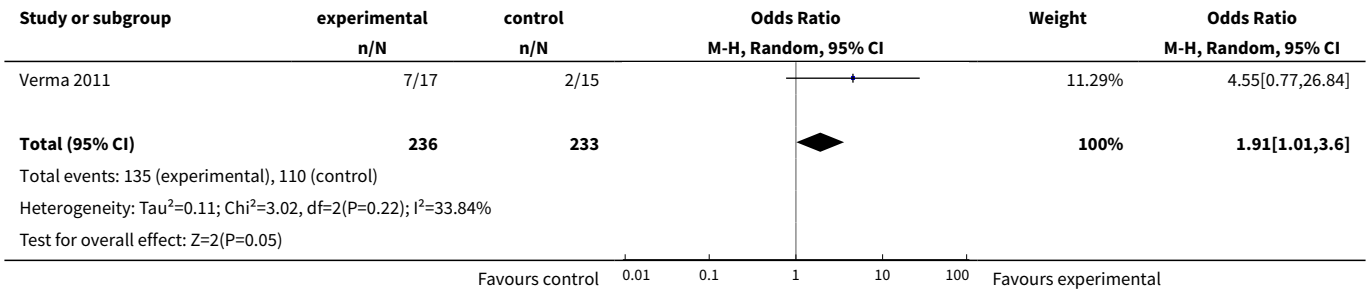


Analysis 1.5. Comparison 1 Circuit class therapy versus other, Outcome 5 Rivermead Mobility Index.

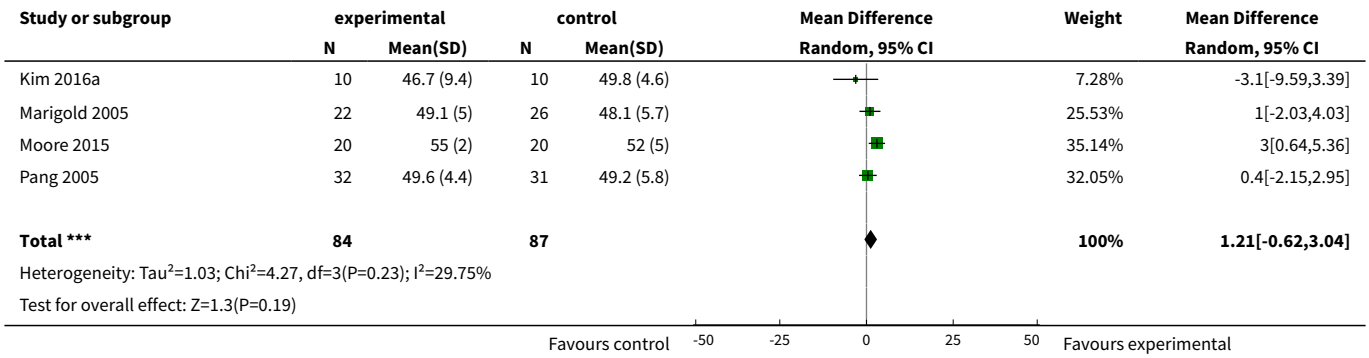


Analysis 1.6. Comparison 1 Circuit class therapy versus other, Outcome 6 Functional Ambulation Classification.

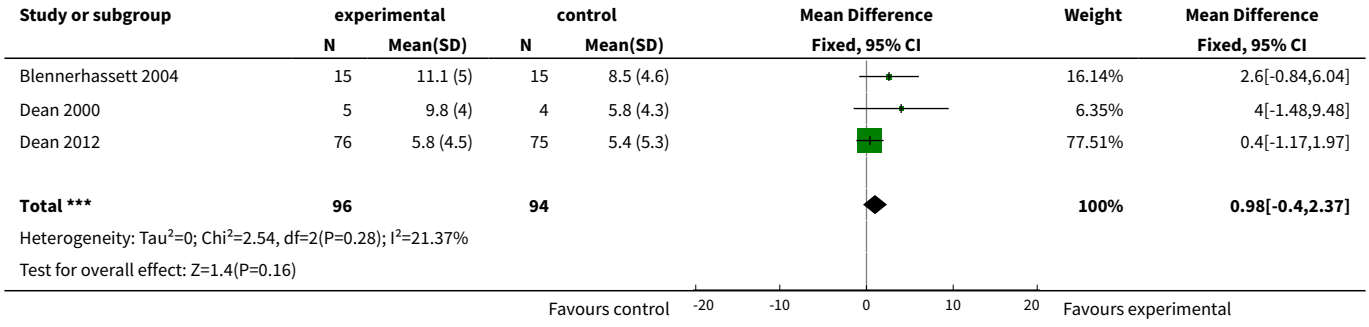




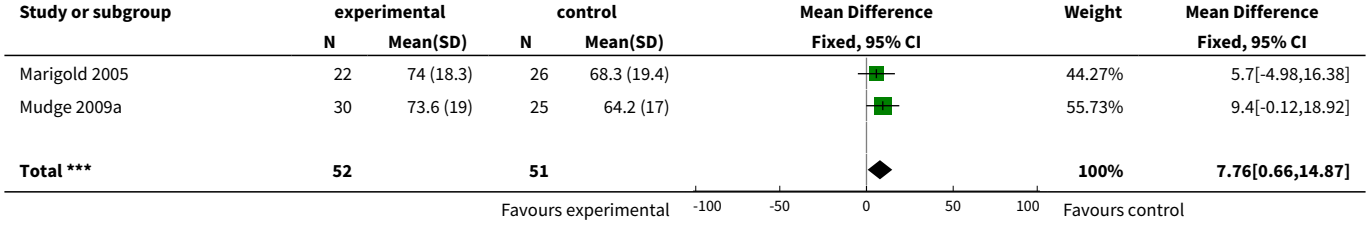
Analysis 1.7. Comparison 1 Circuit class therapy versus other, Outcome 7 Berg Balance Scale.

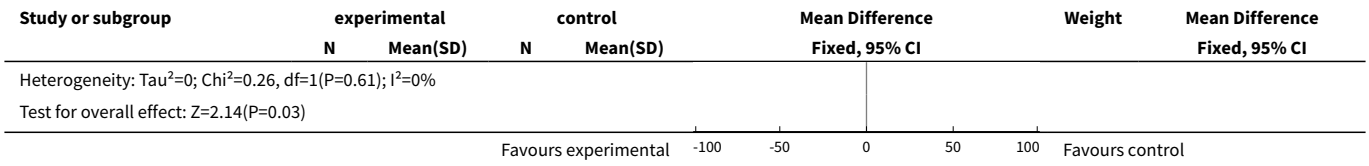


Analysis 1.8. Comparison 1 Circuit class therapy versus other, Outcome 8 Step Test.

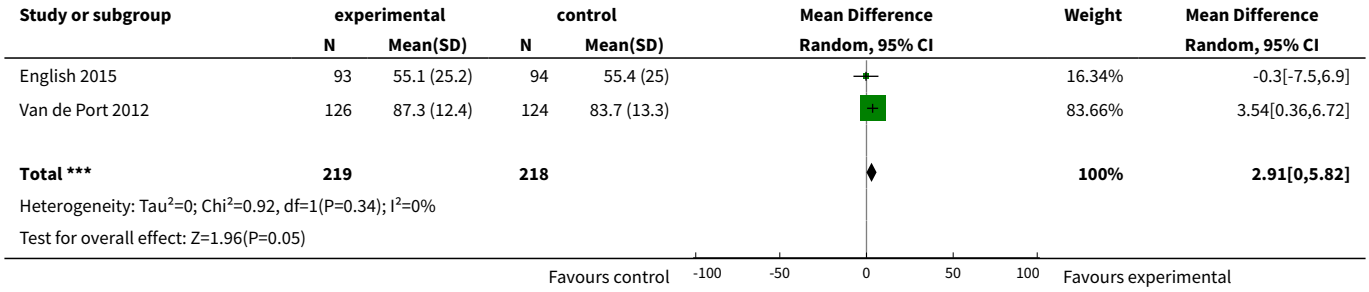


Analysis 1.9. Comparison 1 Circuit class therapy versus other, Outcome 9 Activities-specific Balance Confidence Scale.

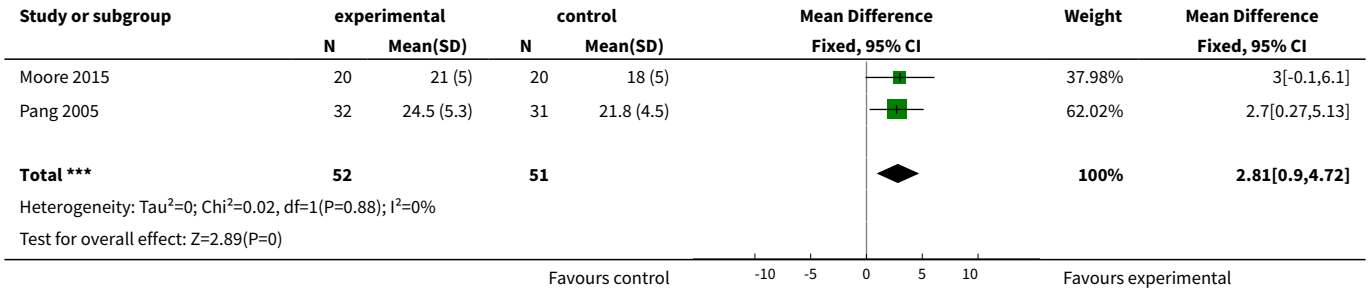




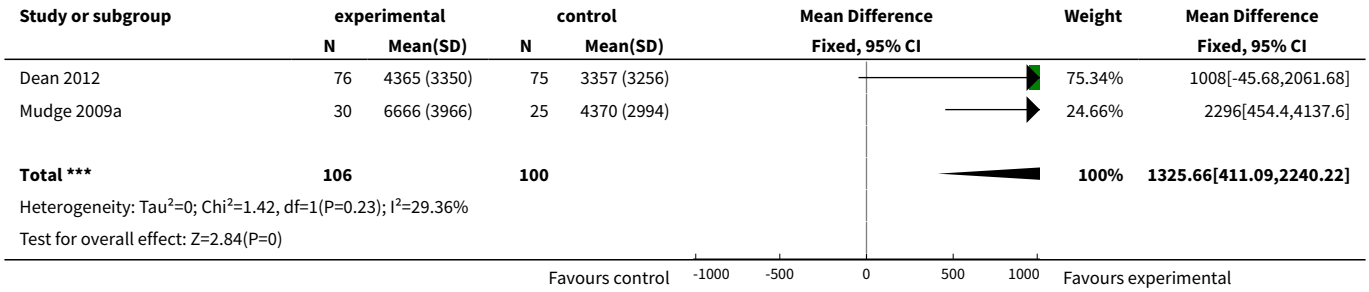
Analysis 1.10. Comparison 1 Circuit class therapy versus other, Outcome 10 Stroke Impact Scale (physical).



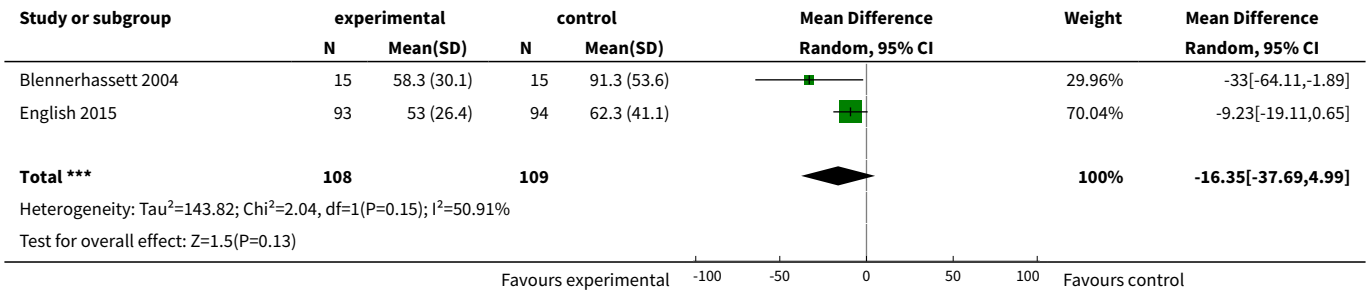
Analysis 1.11. Comparison 1 Circuit class therapy versus other, Outcome 11 VO2 peak.



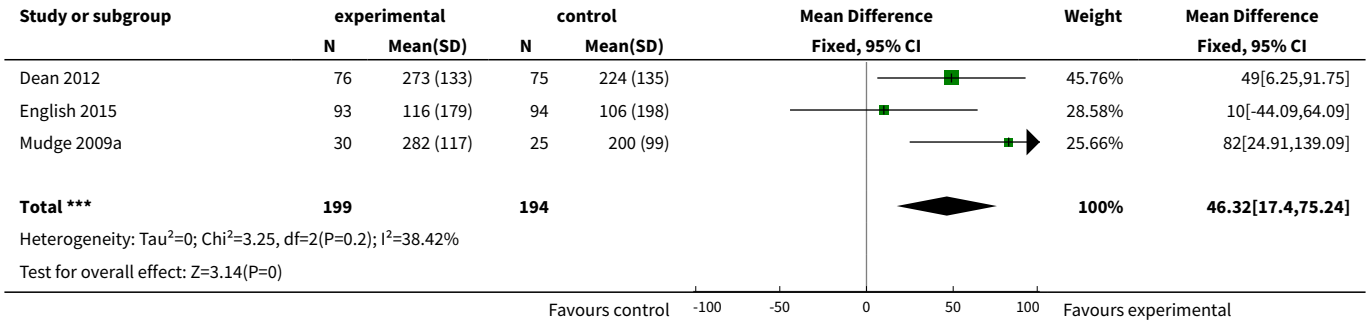
Analysis 1.12. Comparison 1 Circuit class therapy versus other, Outcome 12 Steps per day.



Analysis 1.13. Comparison 1 Circuit class therapy versus other, Outcome 13 Length of stay.



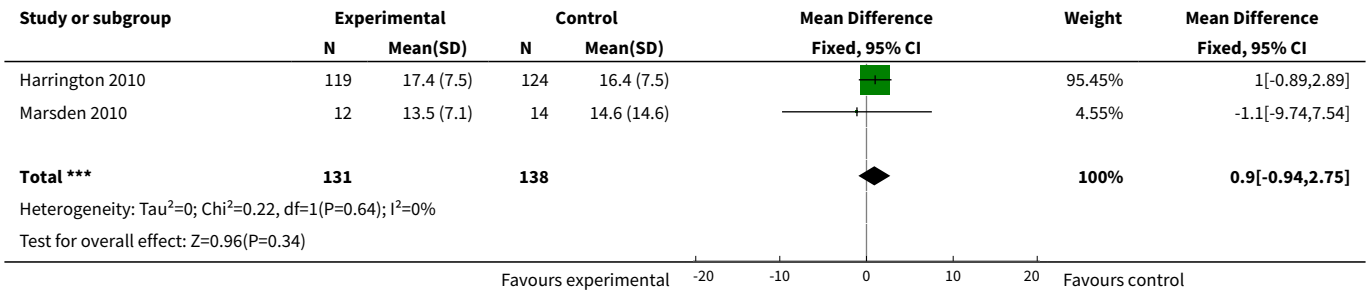
Analysis 1.14. Comparison 1 Circuit class therapy versus other, Outcome 14 Sensitivity: 6mWT.



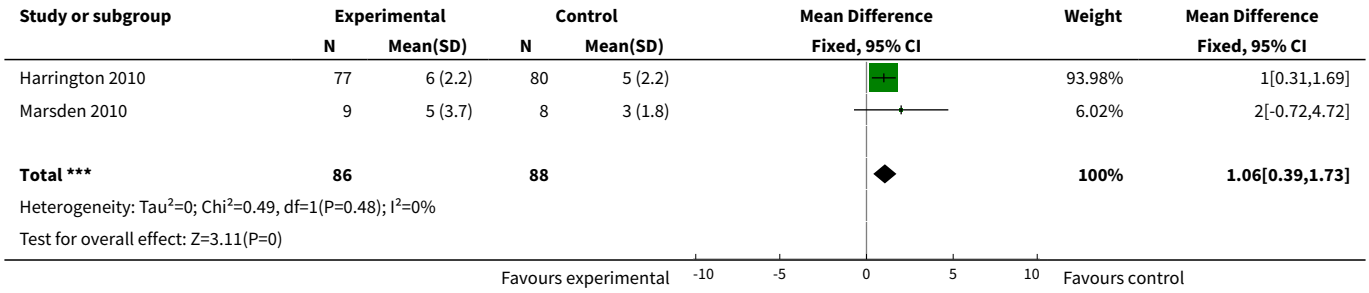
Comparison 2. CCT + education versus no therapy

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Timed Up and Go	2	269	Mean Difference (IV, Fixed, 95% CI)	0.90 [-0.94, 2.75]
2 Carer Strain Index	2	174	Mean Difference (IV, Fixed, 95% CI)	1.06 [0.39, 1.73]

Analysis 2.1. Comparison 2 CCT + education versus no therapy, Outcome 1 Timed Up and Go.



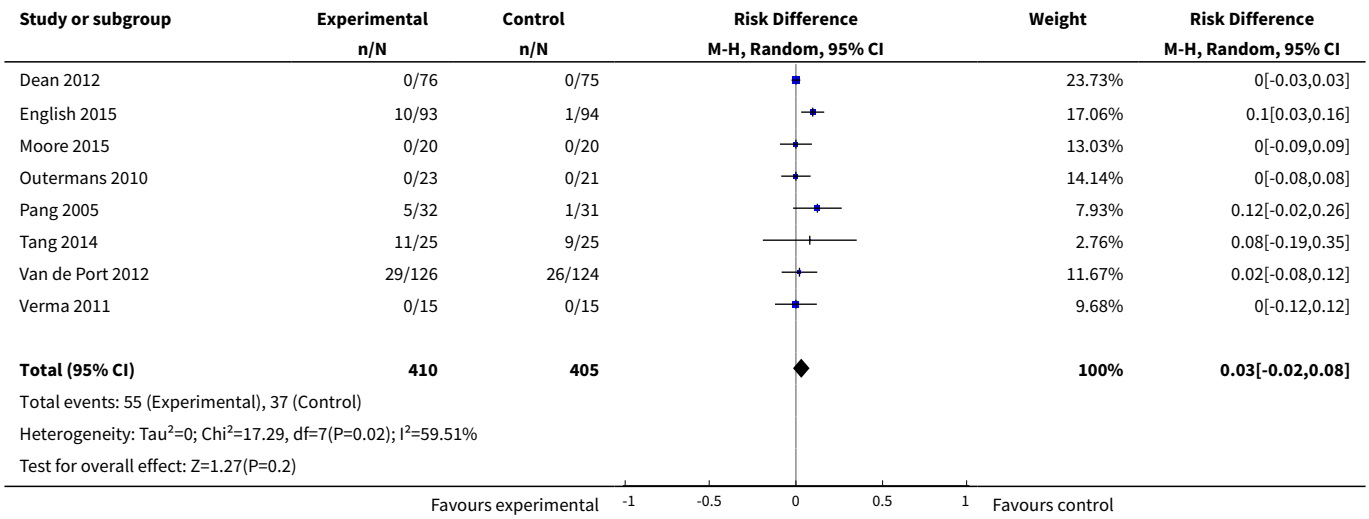
Analysis 2.2. Comparison 2 CCT + education versus no therapy, Outcome 2 Carer Strain Index.



Comparison 3. CCT +/- education versus any other intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Adverse events (falls)	8	815	Risk Difference (M-H, Random, 95% CI)	0.03 [-0.02, 0.08]

Analysis 3.1. Comparison 3 CCT +/- education versus any other intervention, Outcome 1 Adverse events (falls).



ADDITIONAL TABLES

Table 1. Summary of circuit class content in all trials

Study ID	What (CCT content)	Who	How (timing, number and duration of sessions)	Where

Table 1. Summary of circuit class content in all trials *(Continued)*

Blennerhassett 2004	Mobility CCT in addition to usual care; functional tasks, strengthening exercises	Physiotherapist	1-hour sessions 5 days per week for 4 weeks	Inpatient rehabilitation unit
Dean 2000	Multiple task-specific training strengthening LL; practice locomotor-related tasks	Physiotherapists	1-hour sessions, 3 days per week for 4 weeks	Community setting
Dean 2012	Progressive balance and strengthening exercises; walking and stair climbing. Home exercise programme and advice to increase walking	Physiotherapist	45 to 60 minutes per week for 40 weeks over a one-year period	Community setting
English 2015	Task-specific, part- as well as whole-practice of tasks; emphasis on repetition and feedback	Physiotherapists, assistants, and physiotherapy students	90-minute sessions, 5 times per week for 4 weeks	Inpatient rehabilitation
Harrington 2010	Individual, easily progressed; balance, endurance, strength, flexibility, function and well-being. Home exercise manuals and encouraged for on-going exercise	Instructor and physiotherapist with support from volunteers (partners, carers, family members)	2 sessions per week for 8 weeks. (1 hour exercise plus 1 hour interactive education	Community setting
Holmgren 2010	Individualised physical activity, functional performance; educational group discussions about fall risk and security	Physiotherapist and occupational therapist	7 sessions per week divided over 3 days for 5 weeks	Community setting
Kim 2016a	Progressive, focused on mobility and gait training as well as physical fitness	Physiotherapist	90-minute sessions, 5 days per week for 4 weeks	Inpatient rehabilitation
Marigold 2005	Focused on walking, standing, balance, and sit-to-stand tasks	Physical therapist, kinesiologist, and recreation therapist	1-hour sessions, 3 times per week for 10 weeks	Community setting
Marsden 2010	Education and exercises for LL function: functional tasks, strength training and balance training	Multidisciplinary team including a physiotherapist, social worker, dietician, clinical nurse consultant, speech pathologist and occupational therapist	2-hour sessions (1 hour education + 1 hour exercise) weekly for 7 weeks	Community setting
Moore 2015	Functional movement including stretching, functional strengthening, balance, agility and fitness	Physiotherapist and physical activity instructor	3 x 45- to 60-minute sessions per week for 19 weeks	Community setting
Mudge 2009a	Task-oriented gait or standing balance activity, strengthening LL	Physiotherapist and 2 physiotherapy students	50- to 60-minute sessions, 3 times a week for 4 weeks	Community setting
Outermans 2010	Postural control and gait-related activities: stair climbing, walking and turning	Therapists	45-minute sessions, 3 times per week for 4 weeks	Inpatient and outpatient settings

Table 1. Summary of circuit class content in all trials *(Continued)*

Pang 2005	Fitness and mobility exercise: cardiorespiratory fitness, mobility, leg muscle strength, balance, and hip bone mineral density	Physical therapist, occupational therapist, and exercise instructor	1-hour sessions, 3 times per week for 19 weeks	Community setting
Song 2015	Functional training tasks	Physiotherapists	30-minute sessions, 3 times per week for 4 weeks	Inpatient rehabilitation
Tang 2014	Brisk level and inclined overground walking, upright and recumbent cycle ergometry, functional movements	3 instructors	60-minute classes, 3 times per week for 6 months	Community setting
Van de Port 2012	Meaningful tasks related to walking competency	Physiotherapist and sports therapists	90-minute sessions, 2 times per week for 12 weeks	Community setting
Verma 2011	Meaningful tasks related to walking competency: balance control, stair walking, turning, transfers, and speed walking	Physiotherapist or occupational therapist 1 caretaker to ensure safety	40-minute sessions, 7 days per week for 2 weeks	Inpatient and outpatient settings

CCT: circuit class therapy
LL: lower limb

APPENDICES

Appendix 1. CENTRAL search strategy

1. [mh ^"cerebrovascular disorders"] or [mh "basal ganglia cerebrovascular disease"] or [mh "brain ischemia"] or [mh "carotid artery diseases"] or [mh "intracranial arterial diseases"] or [mh "intracranial arteriovenous malformations"] or [mh "intracranial embolism and thrombosis"] or [mh "intracranial hemorrhages"] or [mh ^stroke] or [mh "brain infarction"] or [mh ^"stroke, lacunar"] or [mh ^"vasospasm, intracranial"] or [mh ^"vertebral artery dissection"]
2. (stroke or poststroke or post-stroke or cerebrovasc* or brain next vasc* or cerebral next vasc* or cva* or apoplex* or SAH):ti,ab,kw (Word variations have been searched)
3. ((brain* or cerebr* or cerebell* or intracran* or intracerebral) near/5 (isch*emi* or infarct* or thrombo* or emboli* or occlus*)):ti,ab,kw (Word variations have been searched)
4. ((brain* or cerebr* or cerebell* or intracerebral or intracranial or subarachnoid) near/5 (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*)):ti,ab,kw (Word variations have been searched)
5. [mh ^hemiplegia] or [mh paresis]
6. (hempar* or hemipleg* or brain next injur*):ti,ab,kw (Word variations have been searched)
7. [mh "gait disorders, neurologic"]
8. {or #1-#6}
9. [mh ^"exercise movement techniques"] or [mh ^"exercise therapy"] or [mh ^"muscle stretching exercises"] or [mh ^"plyometric exercise"] or [mh ^"resistance training"] or [mh ^walking]
10. [mh ^"physical fitness"] or [mh ^"physical exertion"] or [mh ^"physical endurance"] or [mh locomotion]
11. [mh ^sports] or [mh ^bicycling] or [mh ^gymnastics] or [mh ^"weight lifting"] or [mh ^running]
12. [mh ^"task performance and analysis"] or [mh ^"athletic performance"] or [mh ^"mobility limitation"]
13. [mh ^"physical therapy modalities"] or [mh ^"physical therapy specialty"]
14. (physical near/3 (exercise* or therap* or conditioning or activit* or fitness or endurance)):ti,ab,kw (Word variations have been searched)
15. (exercise near/3 (train* or intervention* or protocol* or program* or therap* or activit* or regim*)):ti,ab,kw (Word variations have been searched)
16. (fitness near/3 (train* or intervention* or protocol* or program* or therap* or activit* or regim*)):ti,ab,kw (Word variations have been searched)
17 ((training or conditioning) near/3 (intervention* or protocol* or program* or activit* or regim*)):ti,ab,kw (Word variations have been searched)

18. (sport* or cycl* or bicycl* or treadmill* or run* or walk*):ti,ab,kw (Word variations have been searched)
19. muscle strengthening:ti,ab,kw (Word variations have been searched)
20. ((weight or strength or resistance) near (train* or lift* or exercise*)):ti,ab,kw (Word variations have been searched)
21. {or #9-#20}
22. [mh ^"fitness centers"] or [mh ^"sports equipment"]
23. (circuit near/3 (class or classes or therapy or training or program* or exercise* or arranged or arrangement)):ti,ab,kw (Word variations have been searched)
24. (sport* equipment or station or work station):ti,ab,kw (Word variations have been searched)
25. (fitness near/3 (center* or centre* or group* or class or classes or training or program*)):ti,ab,kw (Word variations have been searched)
26. (exercise* near/3 (routine* or group* or class or classes)):ti,ab,kw (Word variations have been searched)
27. ((task-related or sequential) near/3 exercise):ti,ab,kw (Word variations have been searched)
28. group environment:ti,ab,kw (Word variations have been searched)
29. (repetitive pract* or functional task*):ti,ab,kw (Word variations have been searched)
30. {or #22-#29}
31. [mh ^"cerebrovascular disorders"/RH] or [mh "basal ganglia cerebrovascular disease"/RH] or [mh "brain ischemia"/RH] or [mh "carotid artery diseases"/RH] or [mh "intracranial arterial diseases"/RH] or [mh "intracranial arteriovenous malformations"/RH] or [mh "intracranial embolism and thrombosis"/RH] or [mh "intracranial hemorrhages"/RH] or [mh ^stroke/RH] or [mh "brain infarction"/RH] or [mh ^"stroke, lacunar"/RH] or [mh ^"vasospasm, intracranial"/RH] or [mh ^"vertebral artery dissection"/RH]
32. #8 and #21
33. #31 or #32
34. #30 and #33

Appendix 2. MEDLINE search strategy

We used the following search strategy for MEDLINE (Ovid) and adapted it to search the other databases. As the subject area of this review is quite specific we did not include a trials filter. This increased the sensitivity of the search.

MEDLINE (Ovid)

1. cerebrovascular disorders/ or exp basal ganglia cerebrovascular disease/ or exp brain ischemia/ or exp carotid artery diseases/ or exp intracranial arterial diseases/ or exp "intracranial embolism and thrombosis"/ or exp intracranial hemorrhages/ or stroke/ or exp brain infarction/ or vasospasm, intracranial/ or vertebral artery dissection/
2. (stroke or poststroke or post-stroke or cerebrovasc$ or brain vasc$ or cerebral vasc$ or cva$ or apoplex$ or SAH).tw.
3. ((brain$ or cerebr$ or cerebell$ or intracran$ or intracerebral) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$)).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracranial or subarachnoid) adj5 (haemorrhage$ or hemorrhage$ or haematoma$ or hematoma$ or bleed$)).tw.
5. hemiplegia/ or exp paresis/
6. (hemipleg$ or hemipar$ or paresis or paretic).tw.
7. exp gait disorders, neurologic/
8. or/1-7
9. exercise movement techniques/ or exercise therapy/ or muscle stretching exercises/ or plyometric exercise/ or resistance training/ or walking/
10. physical fitness/ or physical exertion/ or physical endurance/ or exp locomotion/
11. sports/ or bicycling/ or gymnastics/ or weight lifting/ or running/
12. "task performance and analysis"/ or athletic performance/ or mobility limitation/
13. physical therapy modalities/ or physical therapy specialty/
14. (physical adj3 (exercise$ or therap$ or conditioning or activit$ or fitness or endurance)).tw.
15. (exercise adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
16. (fitness adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
17. ((training or conditioning) adj3 (intervention$ or protocol$ or program$ or activit$ or regim$)).tw.
18. (sport$ or cycl$ or bicycl$ or treadmill$ or run$ or walk$).tw.
19. muscle strengthening.tw.
20. ((weight or strength or resistance) adj (train$ or lift$ or exercise$)).tw.
21. 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20
22. fitness centers/ or sports equipment/
23. (circuit adj3 (class or classes or therapy or training or program$ or exercise$ or arranged or arrangement)).tw.
24. (sport$ equipment or station or work station).tw.
25. (fitness adj3 (center$ or centre$ or group$ or class or classes or training or program$)).tw.
26. (exercise$ adj3 (routine$ or group$ or class or classes)).tw.
27. ((task-related or sequential) adj3 exercise$).tw.
28. group environment.tw.
29. (repetitive pract$ or functional task$).tw.
30. 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29

31. cerebrovascular disorders/rh or exp basal ganglia cerebrovascular disease/rh or exp brain ischemia/rh or exp carotid artery diseases/rh or exp intracranial arterial diseases/rh or exp "intracranial embolism and thrombosis"/rh or exp intracranial hemorrhages/rh or stroke/rh or exp brain infarction/rh or vasospasm, intracranial/rh or vertebral artery dissection/rh
32. 8 and 21
33. 31 or 32
34. 30 and 33
35. limit 34 to human

Appendix 3. Embase search strategy

1. cerebrovascular disease/ or brain disease/ or exp basal ganglion hemorrhage/ or exp brain hemangioma/ or exp brain hematoma/ or exp brain hemorrhage/ or exp brain infarction/ or exp brain ischemia/ or exp carotid artery disease/ or exp cerebral artery disease/ or exp cerebrovascular accident/ or exp cerebrovascular malformation/ or exp intracranial aneurysm/ or exp occlusive cerebrovascular disease/ or exp vertebrobasilar insufficiency/
2. (stroke$ or poststroke or apoplex$ or cerebral vasc$ or brain vasc$ or cerebrovasc$ or cva$ or SAH).tw.
3. ((brain or cerebr$ or cerebell$ or vertebrobasil$ or hemispher$ or intracran$ or intracerebral or infratentorial or supratentorial or middle cerebral artery or MCA$ or anterior circulation or posterior circulation or basilar artery or vertebral artery or space-occupying) adj5 (isch? emi$ or infarct$ or thrombo$ or emboli$ or occlus$ or hypoxi$)).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracran$ or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli$ or putaminal or putamen or posterior fossa or hemispher$ or subarachnoid) adj5 (h?emorrhag$ or h? ematoma$ or bleed$)).tw.
5. hemiparesis/ or hemiplegia/ or paresis/
6. (hemipleg$ or hemipar$ or paresis or paretic).tw.
7. 1 or 2 or 3 or 4 or 5 or 6
8. exp kinesiotherapy/ or stretching exercise/ or muscle stretching/ or muscle exercise/ or plyometrics/ or resistance training/ or walking/ or exercise/ or circuit training/ or endurance training/
9. fitness/ or exercise intensity/ or endurance/ or exp locomotion/
10. physical activity/ or sport/ or body building/ or cycling/ or endurance sport/ or jogging/ or running/ or weight lifting/
11. task performance/ or physical performance/ or athletic performance/ or walking difficulty/
12. physiotherapy/
13. (physical adj3 (exercise$ or therap$ or conditioning or activit$ or fitness or endurance)).tw.
14. (exercise adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
15. (fitness adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
16. ((training or conditioning) adj3 (intervention$ or protocol$ or program$ or activit$ or regim$)).tw.
17. (sport$ or cycl$ or bicycl$ or treadmill$ or run$ or walk$).tw.
18. muscle strengthening.tw.
19. ((weight or strength or resistance) adj (train$ or lift$ or exercise$)).tw.
20. 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19
21. health center/ or exp sports equipment/
22. (circuit adj3 (class or classes or therapy or training or program$ or exercise$ or arranged or arrangement)).tw.
23. (sports equipment or station or work station).tw.
24. (fitness adj3 (center$ or centre$ or group$ or class or classes or training or program$)).tw.
25. (exercise$ adj3 (routine$ or group$ or class or classes)).tw.
26. ((task-related or sequential) adj3 exercise$).tw.
27. group environment.tw.
28. (repetitive pract$ or functional task$).tw.
29. 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28
30. cerebrovascular disease/rh or brain disease/rh or exp basal ganglion hemorrhage/rh or exp brain hemangioma/rh or exp brain hematoma/rh or exp brain hemorrhage/rh or exp brain infarction/rh or exp brain ischemia/rh or exp carotid artery disease/rh or exp cerebral artery disease/rh or exp cerebrovascular accident/rh or exp cerebrovascular malformation/rh or exp intracranial aneurysm/rh or exp occlusive cerebrovascular disease/rh or exp vertebrobasilar insufficiency/rh
31. 7 and 20
32. 30 or 31
33. 29 and 32

Appendix 4. CINAHL search strategy

S1 (MH "Cerebrovascular Disorders") OR (MH "Basal Ganglia Cerebrovascular Disease+") OR (MH "Carotid Artery Diseases+") OR (MH "Cerebral Ischemia+") OR (MH "Cerebral Vasospasm") OR (MH "Intracranial Arterial Diseases+") OR (MH "Intracranial Embolism and Thrombosis") OR (MH "Intracranial Hemorrhage+") OR (MH "Stroke") OR (MH "Vertebral Artery Dissections")
S2 (MH "Stroke Patients") OR (MH "Stroke Units")
S3 TI (stroke* or poststroke or apoplex* or cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH) or AB (stroke* or poststroke or apoplex* or cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH)

S4 TI (brain or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or middle cerebral artery or MCA* or anterior circulation or posterior circulation or basilar artery or vertebral artery or space-occupying) or AB (brain or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or middle cerebral artery or MCA* or anterior circulation or posterior circulation or basilar artery or vertebral artery or space-occupying)
S5 TI (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus* or hypoxi*) or AB (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus* or hypox*)
S6 S4 and S5
S7 TI (brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal or putamen or posterior fossa or hemispher* or subarachnoid) or AB (brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal or putamen or posterior fossa or hemispher* or subarachnoid)
S8 TI (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*) or AB (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*)
S9 S7 and S8
S10 (MH "Hemiplegia")
S11 TI (hemipleg* or hemipar* or paresis or paretic) or AB (hemipleg* or hemipar* or paresis or paretic)
S12 S1 OR S2 OR S3 OR S6 OR S9 OR S10 OR S11
S13 (MH "Exercise") OR (MH "Therapeutic Exercise") OR (MH "Muscle Strengthening") OR (MH "Stretching") OR (MH "Plyometrics") OR (MH "Group Exercise") OR (MH "Muscle Strengthening") OR (MH "Resistance Training")
S14 (MH "Physical Fitness") OR (MH "Physical Performance") OR (MH "Physical Activity") OR (MH "Physical Endurance+") OR (MH "Muscle Strength") OR (MH "Locomotion+")
S15 (MH "Sports") OR (MH "Cycling") OR (MH "Gymnastics") OR (MH "Weight Lifting") OR (MH "Running") OR (MH "Jogging")
S16 (MH "Task Performance and Analysis") OR (MH "Athletic Performance") OR (MH "Physical Mobility")
S17 (MH "Physical Therapy")
S18 (TI physical AND TI ((exercise* or therap* or conditioning or activit* or fitness or endurance))) OR (AB physical AND AB ((exercise* or therap* or conditioning or activit* or fitness or endurance)))
S19 (TI exercise AND TI ((train* or intervention* or protocol* or program* or therap* or activit* or regim*))) OR (AB exercise AND AB ((train* or intervention* or protocol* or program* or therap* or activit* or regim*)))
S20 (TI fitness AND TI ((train* or intervention* or protocol* or program* or therap* or activit* or regim*))) OR (AB fitness AND AB ((train* or intervention* or protocol* or program* or therap* or activit* or regim*)))
S21 (TI ((training or conditioning)) AND TI ((intervention* or protocol* or program* or activit* or regim*))) OR (AB ((training or conditioning)) AND AB ((intervention* or protocol* or program* or activit* or regim*)))
S22 TI ((sport* or cycl* or bicycl* or treadmill* or run* or walk*)) OR AB ((sport* or cycl* or bicycl* or treadmill* or run* or walk*))
S23 TI muscle strengthening OR AB muscle strengthening
S24 (TI ((weight or strength or resistance)) AND TI ((train* or lift* or exercise*))) OR (AB ((weight or strength or resistance)) AND AB ((train* or lift* or exercise*)))
S25 S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24
S26 (MH "Fitness Centers") OR ((MH "Sports Equipment and Supplies"))
S27 (TI circuit AND TI ((class or classes or therapy or training or program* or exercise* or arranged or arrangement))) OR (AB circuit AND AB ((class or classes or therapy or training or program* or exercise* or arranged or arrangement)))
S28 TI ((sports equipment or station or work station)) OR AB ((sports equipment or station or work station))
S29 (TI fitness AND TI ((center* or centre* or group* or class or classes or training or program*))) OR (AB fitness AND AB ((center* or centre* or group* or class or classes or training or program*)))
S30 (TI exercise* AND TI ((routine* or group* or class or classes))) OR (AB exercise* AND AB ((routine* or group* or class or classes)))
S31 (TI ((task-related or sequential)) AND TI exercise*) OR (AB ((task-related or sequential)) AND AB exercise*)
S32 TI group environment OR AB group environment
S33 TI ((repetitive pract* or functional task*)) OR AB ((repetitive pract* or functional task*))
S34 S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33
S35 (MH "Cerebrovascular Disorders/RH") OR (MH "Basal Ganglia Cerebrovascular Disease+/RH") OR (MH "Carotid Artery Diseases+/RH") OR (MH "Cerebral Ischemia+/RH") OR (MH "Cerebral Vasospasm/RH") OR (MH "Intracranial Arterial Diseases+/RH") OR (MH "Intracranial Embolism and Thrombosis/RH") OR (MH "Intracranial Hemorrhage+/RH") OR (MH "Stroke/RH") OR (MH "Vertebral Artery Dissections/RH")
S36 S9 AND S25
S37 S35 OR S36
S38 S34 AND S37

Appendix 5. PsycINFO search strategy

1. cerebrovascular disorders/ or cerebral hemorrhage/ or cerebral ischemia/ or cerebrovascular accidents/
2. (stroke or poststroke or post-stroke or cerebrovasc$ or brain vasc$ or cerebral vasc$ or cva$ or apoplex$ or SAH).tw.
3. ((brain$ or cerebr$ or cerebell$ or intracran$ or intracerebral) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$)).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracranial or subarachnoid) adj5 (haemorrhage$ or hemorrhage$ or haematoma $ or hematoma$ or bleed$)).tw.

5. paralysis/ or hemiplegia/
6. (hemipleg$ or hemipar$ or paresis or paretic).tw.
7. 1 or 2 or 3 or 4 or 5 or 6
8. aerobic exercise/ or physical fitness/ or exercise/ or movement therapy/ or walking/ or locomotion/
9. physical activity/ or physical mobility/ or physical agility/ or physical dexterity/ or physical therapy/
10. athletic training/ or athletic performance/ or sports medicine/ or sports/ or weightlifting/
11. (physical adj3 (exercise$ or therap$ or conditioning or activit$ or fitness or endurance)).tw.
12. (exercise adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
13. (fitness adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
14. ((training or conditioning) adj3 (intervention$ or protocol$ or program$ or activit$ or regim$)).tw.
15. (sport$ or cycl$ or bicycl$ or treadmill$ or run$ or walk$).tw.
16. muscle strengthening.tw.
17. ((weight or strength or resistance) adj (train$ or lift$ or exercise$)).tw.
18. or/8-17
19. apparatus/
20. (circuit adj3 (class or classes or therapy or training or program$ or exercise$ or arranged or arrangement)).tw.
21. (sport$ equipment or station or work station).tw.
22. (fitness adj3 (center$ or centre$ or group$ or class or classes or training or program$)).tw.
23. (exercise$ adj3 (routine$ or group$ or class or classes)).tw.
24. ((task-related or sequential) adj3 exercise$).tw.
25. group environment.tw.
26. (repetitive pract$ or functional task$).tw.
27. or/19-26
28. 27 and 18 and 7

Appendix 6. AMED search strategy

1. cerebrovascular disorders/ or cerebral hemorrhage/ or cerebral infarction/ or cerebral ischemia/ or cerebrovascular accident/ or stroke/
2. (stroke or poststroke or post-stroke or cerebrovasc$ or brain vasc$ or cerebral vasc$ or cva$ or apoplex$ or SAH).tw.
3. ((brain$ or cerebr$ or cerebell$ or intracran$ or intracerebral) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$)).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracranial or subarachnoid) adj5 (haemorrhage$ or hemorrhage$ or haematoma $ or hematoma$ or bleed$)).tw.
5. hemiplegia/
6. (hemipleg$ or hemipar$ or paresis or paretic).tw.
7. 1 or 2 or 3 or 4 or 5 or 6
8. exp exercise/ or physical fitness/ or exertion/ or lifting/ or exp physical endurance/ or immobility/ or resistance training/
9. sports/ or bicycling/ or gymnastics/ or exp locomotion/
10. physical therapy modalities/ or physical therapy speciality/
11. (physical adj3 (exercise$ or therap$ or conditioning or activit$ or fitness or endurance)).tw.
12. (exercise adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
13. (fitness adj3 (train$ or intervention$ or protocol$ or program$ or therap$ or activit$ or regim$)).tw.
14. ((training or conditioning) adj3 (intervention$ or protocol$ or program$ or activit$ or regim$)).tw.
15. (sport$ or cycl$ or bicycl$ or treadmill$ or run$ or walk$).tw.
16. muscle strengthening.tw.
17. ((weight or strength or resistance) adj (train$ or lift$ or exercise$)).tw.
18. 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17
19. (circuit adj3 (class or classes or therapy or training or program$ or exercise$ or arranged or arrangement)).tw.
20. (sports equipment or station or work station).tw.
21. (fitness adj3 (center$ or centre$ or group$ or class or classes or training or program$)).tw.
22. (exercise$ adj3 (routine$ or group$ or class or classes)).tw.
23. ((task-related or sequential) adj3 exercise$).tw.
24. group environment.tw.
25. (repetitive pract$ or functional task$).tw.
26. 19 or 20 or 21 or 22 or 23 or 24 or 25
27. 7 and 18 and 26

Appendix 7. SPORTDiscus

S1 DE "CEREBROVASCULAR disease" OR DE "BRAIN -- Hemorrhage" OR DE "CEREBRAL embolism & thrombosis" OR DE "STROKE" OR DE "BRAIN -- Wounds & injuries" OR DE "BRAIN damage" OR DE "CEREBROVASCULAR disease -- Patients"
S2 TI (stroke or poststroke or post-stroke or cerebrovasc* or brain vasc* or cerebral vasc or cva or apoplex or SAH) or AB (stroke or poststroke or post-stroke or cerebrovasc* or brain vasc* or cerebral vasc or cva or apoplex or SAH)

S3 (TI (brain* or cerebr* or cerebell* or intracran* or intracerebral) or AB (brain* or cerebr* or cerebell* or intracran* or intracerebral)) and (TI (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*) or AB (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*))
S4 (TI (brain* or cerebr* or cerebell* or intracerebral or intracranial or subarachnoid) or AB (brain* or cerebr* or cerebell* or intracerebral or intracranial or subarachnoid)) and (TI (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*) or AB (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*))
S5 DE "HEMIPLEGIA" OR DE "HEMIPLEGICS" OR DE "GAIT disorders"
S6 TI (hemipleg* or hemipar* or paresis or paretic) or AB (hemipleg* or hemipar* or paresis or paretic)
S7 S1 OR S2 OR S3 OR S4 OR S5 OR S6
S8 DE "EXERCISE" OR DE "EXERCISE -- Equipment & supplies" OR DE "EXERCISE intensity" OR DE "EXERCISE physiology" OR DE "EXERCISE therapy"
S9 (((DE "MUSCLE strength" OR DE "MUSCLE weakness") OR (DE "PLYOMETRICS")) OR (DE "RESISTANCE training (Physical training & conditioning)")) AND (DE "WALKING" OR DE "WALKING (Sports)" OR DE "WALKING (Sports) -- Training")
S10 ((DE "PHYSICAL fitness") OR (DE "ENDURANCE sports" OR DE "ULTRAENDURANCE sports")) OR (DE "LOCOMOTION")
S11 (DE "WEIGHT lifting" OR DE "BENCH press" OR DE "DEAD lift (Weight lifting)" OR DE "POWERLIFTING" OR DE "SQUAT (Weight lifting)" OR DE "WEIGHT lifting competitions") OR (DE "RUNNING")
S12 (DE "PHYSICAL therapy" OR DE "SPORTS physical therapy" OR DE "RECOVERY training") OR (DE "CIRCUIT training")
S13 (TI physical AND TI ((exercise* or therap* or conditioning or activit* or fitness or endurance))) OR (AB physical AND AB ((exercise* or therap* or conditioning or activit* or fitness or endurance)))
S14 (TI exercise AND TI ((train* or intervention* or protocol* or program* or therap* or activit* or regim*))) OR (AB exercise AND AB ((train* or intervention* or protocol* or program* or therap* or activit* or regim*)))
S15 (TI fitness AND TI ((train* or intervention* or protocol* or program* or therap* or activit* or regim*))) OR (AB fitness AND AB ((train* or intervention* or protocol* or program* or therap* or activit* or regim*)))
S16 (TI ((training or conditioning)) AND TI ((intervention* or protocol* or program* or activit* or regim*))) OR (AB ((training or conditioning)) AND AB ((intervention* or protocol* or program* or activit* or regim*)))
S17 TI ((sport* or cycl* or bicycl* or treadmill* or run* or walk*)) OR AB ((sport* or cycl* or bicycl* or treadmill* or run* or walk*))
S18 TI muscle strengthening OR AB muscle strengthening
S19 (TI ((weight or strength or resistance)) AND TI ((train* or lift* or exercise*))) OR (AB ((weight or strength or resistance)) AND AB ((train* or lift* or exercise*)))
S20 S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19
S21 DE "PHYSICAL fitness centers" OR DE "WEIGHT training facilities" OR DE "GYMNASIUMS" OR DE "HEALTH facilities" OR DE "EXERCISE -- Equipment & supplies"
S22 (TI circuit AND TI ((class or classes or therapy or training or program* or exercise* or arranged or arrangement))) OR (AB circuit AND AB ((class or classes or therapy or training or program* or exercise* or arranged or arrangement)))
S23 TI ((sports equipment or station or work station)) OR AB ((sports equipment or station or work station))
S24 (TI fitness AND TI ((center* or centre* or group* or class or classes or training or program*))) OR (AB fitness AND AB ((center* or centre* or group* or class or classes or training or program*)))
S25 (TI exercise* AND TI ((routine* or group* or class or classes))) OR (AB exercise* AND AB ((routine* or group* or class or classes)))
S26 (TI ((task-related or sequential)) AND TI exercise*) OR (AB ((task-related or sequential)) AND AB exercise*)
S27 TI group environment OR AB group environment
S28 TI ((repetitive pract* or functional task*)) OR AB ((repetitive pract* or functional task*))
S29 S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28
S30 S7 AND S20 AND S29

WHAT'S NEW

Date	Event	Description
23 June 2017	Amended	Correction to forest plot axis label (Analysis 1.1)

HISTORY

Protocol first published: Issue 1, 2009
Review first published: Issue 7, 2010

Date	Event	Description
28 May 2017	New citation required but conclusions have not changed	Greater number of studies supporting the main conclusion that circuit class therapy is effective at improving mobility for people after stroke.
28 January 2017	New search has been performed	Searches updated and 12 new trials involving 1005 new participants included. This review now includes 17 trials and 1297 participants.
9 July 2010	Amended	Minor correction made to the participant characteristics in the Results section of the Abstract and under Included studies in the main Results section of the review.

CONTRIBUTIONS OF AUTHORS

Coralie English and Susan Hillier were involved in all stages of the review. Elizabeth Lynch assisted in assessing risk of bias and in drafting the text of the updated review. Coralie English and Elizabeth Lynch have experience in the clinical use of CCT and Susan Hillier and Coralie English have experience as review authors. Coralie English and Susan Hillier are guarantors of the review.

DECLARATIONS OF INTEREST

Coralie English: has published a trial investigating the use of CCT with people with stroke (English 2015).
Susan Hillier: has published a trial investigating the use of CCT with people with stroke (English 2015).
Elizabeth Lynch: none known

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The original protocol included quasi-randomised trials: the updated review excluded these due to sufficient randomised trials being found. The primary outcome has been refined to walking capacity (rather than a general outcome of improved mobility) but is still defined operationally as the 6mWT, which is used the most extensively in stroke trials. We have included a 'Summary of findings' table in the main report, along with the approach to determining this table and the GRADE designations (in methods).

INDEX TERMS

Medical Subject Headings (MeSH)

*Walking Speed; Arm [physiology]; Exercise Therapy [adverse effects] [*methods]; Gait [physiology]; Postural Balance [physiology]; Randomized Controlled Trials as Topic; Recovery of Function; Stroke Rehabilitation [*methods]; Walk Test

MeSH check words

Adult; Humans