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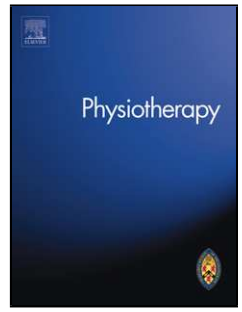

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The effectiveness of group exercise for improving activity and participation in adult stroke survivors: a systematic review

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Abstract

Background: Following post-stroke rehabilitation, group exercise interventions can be used to continue improving cardiovascular fitness, activity levels, balance, gait, movement efficiency, and strengthening. However, little is known of the effectiveness of group exercise for improving activity and participation in stroke survivors.

Objectives: This review aims to assess the effectiveness of group exercise for improving activity and participation in adult stroke survivors.

Data sources: Databases searched were MEDLINE, Web of Science (Core collection), CINAHL, and the Cochrane Library.

Study eligibility criteria: Randomised controlled trials (RCTs) of group exercise using validated outcome measures of activity and participation for post-stroke rehabilitation. Two independent reviewers assessed all abstracts, extracted data, conducted a narrative synthesis and assessed the quality of all included articles. The Cochrane Risk of Bias Tool assessed methodological quality and included outcome measure quality was assessed

Results: 14 RCTs were included (n=624 chronic stroke survivors collectively). Studies ranged between 12 and 243 stroke participants with an average of left:right hemisphere lesions of 32:39 and average age was 66.7 years. Although intervention and control groups improved, no significant difference between group differences were evident.

Conclusion and implications of key findings: The review found improvements are short-term and less evident at long-term follow up with little improvements in participation after six months. However, this review was limited to the standard of intervention reporting. Further research should consider consistency in measuring underpinning mechanisms of group exercise interventions, which may explain the lack of activity changes in long-term follow-up.

PROSPERO: CRD42017078917

Contribution of the paper

- Improvements in activity and participation in chronic stroke survivors who take part in community group exercise schemes are short term and less evident longer term.
- This review recommends that future research should consider using alternative methodologies to measure the underpinning mechanisms of group exercise interventions.
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- **Abbreviations**
- RCT – Randomised controlled trial
- UK - United Kingdom
- NHS – National Health Service
- ICF – International Classification of Functioning Disability and Health
- PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analysis
- CVA – Cardiovascular Accident
- TIA – Transient Ischemic Attack
- HIIT – High Intensity Interval Training
- MeSH – Medical Subject Heading
- EBRSR - Evidence Based Review of Stroke Rehabilitation
- MCID - Minimally Clinically Important Difference
- TUG – Timed Up and Go Test
- 6MWT – 6 Minute Walk Test
- MAS-arm – Motor Assessment Scale upper lib – arm
- MAS-hand – Motor Assessment Scale upper limb – hand
- WMFT – Wolf Motor Function Test
- SIS – Stroke Impact Scale
- FAI – Frenchay Activities Index

- RMI - Rivermead Mobility Index
- NHP - Nottingham Health Profile
- SF36 - Medical outcomes study 36-item short form questionnaire, version 2
- FIM - Functional Independence Measure
- GHQ – General Health Questionnaire
- HADs – Hospital Anxiety and Depression Scale
- SRD – Smallest Real Difference
- BBS – Berg Balance Scale

Keywords: Stroke, Rehabilitation, group exercise, function, intensity

Introduction

Every two seconds, someone in the world will have a stroke and one in four will experience a further stroke within the first five years. The burden of stroke due to illness, disability and early death is set to double worldwide within the next 15 years [1].

Approximately 35% of stroke survivors with initial paralysis of the lower limb do not regain useful function and 20 to 25% of these survivors are unable to walk without full assistance at 6 months [2]. The remaining 65% of survivors who are able ambulate independently experience an increased effort in walking tasks and changes to physical function and participation in other daily activities [3]. This can cause a loss of fitness, activity and independence which contributes to increased social needs and the development of comorbidities such as diabetes and an increased risk of depression [3].

Following mainstream rehabilitation, community-based group exercise interventions can be used to continue to make improvements to cardiovascular fitness, activity levels, balance, gait, movement efficiency, social integration, peer support and functional strengthening [4]. Group exercise also includes mechanisms such as social learning and self-efficacy theories, namely feedback and persuasion and modelling [5]. It has also been shown that physical activity can be the greatest defence against further stroke (20-35%), depression (20-30%), hypertension (33%) and death (20-35%) [6].

Evidence suggests that improvements in long term outcomes have been shown when rehabilitation and physical activities include underpinning mechanisms such as, task and goal specific, involve intensive repetition in real world activities with variation of force, acceleration and direction while utilising sensory feedback internally and externally from observers [2]. This requires a combination of skill, strength and endurance training. However, although it is recognised that intensity is an essential mechanism [7], it is unclear how the approaches to measuring intensity in community-based exercise interventions are carried out and whether the intensity was maintained or progressed throughout the intervention.

Recent systematic reviews have concluded that group exercise interventions can support changes to walking distance [8], walking related tasks [9] and strength and activity but the degree of these changes is inconsistent. However, these reviews have evaluated the effects of group exercise on the specific outcomes of walking, strength and the effect of strength training on activity only. The International Classification of Functioning, Disability and Health (ICF) has become the main conceptual framework for post stroke rehabilitation [10]. The activities and participation domain of the ICF provides an indication of how interventions may or may not lead to functional and participatory improvements for people in everyday life [11].

Therefore, the aim of this systematic review was to examine how group exercise interventions improves the ICF domain of function and participation in adult stroke survivors. The secondary aim was to explore if and how the mechanism of progressive intensity has been measured for group exercise interventions.

Method

The review protocol was registered with PROSPERO (CRD42017078917) and undertaken in accordance with the general principles recommended in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [12].

Definitions

For this review, group exercise is defined as exercise that is executed by a group of people led by an instructor [13]. Intensity is defined as the energy expended during exercise, measured by heart rate and perceived exertion [14].

Search M*ethods*

The following databases were searched from inception to May 2017: MEDLINE, Web of Science (core collection), CINAHL, and the Cochrane Library. Medical Subject Headings (MeSH) keywords can be found in Appendix one (Medline search strategy).

One to one sessions and home-based interventions were excluded as these to not benefit from group dynamics. Studies using specific interventions such as walking only, treadmill only, cycle only, vibration and upper limb only were excluded because they do not have the variability of exercise required for whole body functional change.

Boolean logic (“AND”, “OR”) was used to combine search terms. MESH terms are used for the purpose of indexing journal articles and books in electronic databases. Free text terms and synonyms were used as specific words that the search strategy looks for in the title and abstract.

Electronic citations were downloaded to Endnote software. The inclusion criteria are described in table 1.

Please insert Table 1 here

In order to answer the research question appropriately, randomised controlled trials (RCTs) were chosen in order to review the effectiveness of the interventions used. Non-RCT evidence was outside the scope of this review.

Comparators are treatment as usual, physical therapy, exercise therapy, conventional therapy or sham stimulation. Changes in activity and participation were the primary outcome measures for this review and were assessed by any of the measures identified from evidence-based review of stroke rehabilitation (EBRSR) outcomes measures [15].

Quality **assessment**

The Cochrane Collaboration risk of bias assessment criteria was used to assess the methodological quality of included RCTs [16]. This tool addresses specific domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective outcome reporting.

During the selective reporting domain, an initial judgement was made that if a trial study protocol had been approved and a report of primary and secondary outcomes was given in the results, then the trial could be considered low risk of selective reporting bias. RCTs were classified as being at overall low risk of bias if they were rated as “low” for these domains:

1. Allocation concealment
2. Blinding of outcome assessment
3. Completeness of outcome data

RCTs judged as being at high risk of bias for any of these domains were judged at overall high risk. When RCTs were judged as having an unclear risk of bias for any of these domains, they were judged at overall unclear risk.

Data extraction

The retrieved titles, abstracts, and/or papers were screened independently by two review authors (GC, LP) to identify studies that met the inclusion criteria. Disagreements were resolved between reviewers through discussion. A standardised excel form was used for data extraction. Details of the RCT characteristics included participants, the intervention, and comparator. Data extraction was carried out by reviewer GC and checked for accuracy by reviewer LP. Missing data were requested from study authors.

Outcome measurement assessment

It is essential that the quality of outcome measures used in each study are assessed to ensure the results are valid and reliable. The three domains of psychometric properties, Minimally Clinically Important Difference (MCID) and the design and analysis for each of the outcome measures used was considered [17].

We identified all outcome measures (N=12) used across the 14 trials and reviewed each measure individually to assess if they fulfilled the first two domains mentioned above. Included outcome measures are outlined in Table 2 and broken down by activity and participation according to the ICF:

Please insert table 2 here

The literature was reviewed for each outcome measure. Each outcome measure was assessed to see how the data was scored, collected and analysed.

Outcome measures were classified against the three domains within the World Health Organisation ICF, as the aim of this review was to examine how group exercise interventions improve activity and participation in adult stroke survivors. Authors excluded measurements of "body structures" (impairment) such as the General Health Questionnaire (GHQ) and Hospital anxiety and depression scale (HAD's). Of the twelve outcome measures included nine were measures of "activity" and three were measure of "participation" as classified by the ICF [15].

Data synthesis

A narrative overview of the included RCTs with supporting evidence tables and text has been presented. A meta-analysis was not undertaken due to the heterogeneity between the primary outcome measures within the studies.

Results

The electronic searches identified 4762 citations and then 4590 citations following de-duplication. Two additional citations were identified through reference searches or other sources. 4288 citations were excluded based on their titles, and 204 based on their abstracts. The authors obtained 98 citations as full-text articles. Of these, 86 were excluded at the full-text stage; details of these excluded studies with the reason for exclusion are shown in Figure 1. Fourteen RCTs reported across fourteen publications were included in this review.

Please insert figure 1 here.

Quality assessment

Full details from the Cochrane risk of bias assessment are presented in Appendix 2. A summary of the risk of bias assessment is presented in Table 3. Two of the included RCTs were judged as having an unclear risk of bias [18, 19]. Both of these RCTs were an unclear risk for allocation concealment and blinding and one of the two RCTs was also unclear for risk for random sequence generation, blinding of participants and personnel and missing data. Four of the included studies had dropout rates >20% ranging from 22-32% and were therefore judged as having a high risk of bias [18, 20-22].The remaining thirteen RCTs were judged as having a low risk of bias overall.

Please insert table 3 here

Quality assessment of measurement scales

A summary of the outcome measurement quality assessment can be found in appendix 3. Twelve of the 14 included RCTs used a combination of ordinal scales of measurement all with established psychometric properties [19-30].

Bohannon undertook a systematic review of MCID in the 6MWT for adults with a variety of pathologies [31]. The findings of this review suggested a change of 14.0 to

30.5 metres may be clinically important across multiple patient groups. Of the six RCTs that used the 6-minute walk test [23, 25, 27, 28, 30, 32], only one study [27] did not demonstrate a MCID in the control group all of the other four studies [20, 22, 26, 29] MCID was reported in both the intervention arm and the control arm, however one RCT [23] demonstarted a MCID in both the Mobility group and the Upper limb group.

Flansbjer et al 2005 [33] suggest that the minimum detectable or smallest real difference (SRD) for the TUG is 2.9s and that is the smallest change that indicates a real clinical improvement in this population group.

Of the seven RCTs that used the TUG [18-21, 23, 25, 32] two studies reported MCID improvements in only the intervention groups [18, 20]. One study [23] reported a MCID in both the Mobility and Upper Limb groups, one study [21] reported a MCID in the Agility group and not the Stretch/Weight Shift group. Dean et al., 2012 reported an MCID between groups at 12 months but this was not statistically significant. Hart et al., 2004 did not report an MCID in any groups.

Thirteen of the fourteen studies [18-28, 30, 32] used outcomes evaluating activity through a combination of the 6MWT, BBS and TUG showed intervention over time improvements, but these were predominantly only evident for a short period of time post intervention up (4-9 weeks). There was little further change at longer term follow up (> 6 months). Eight of the studies [18, 19, 22-24, 27, 29, 30] demonstrated significant changes between intervention and control groups. One [24] showed a near significant change in BBS although both groups were close to the ceiling effect of the measure. Nine Studies [18-23, 26, 28, 32] showed significant improvements with intervention from baseline to post intervention measures although no further significant improvements were noted in long term follow up in six of these [18, 20, 23, 27, 28, 32].

Three studies used participation outcomes including the NHP [21], the SIS [26] and the SF-36 [29]. All outcomes improved during the intervention period with long term improvements at follow up observed in two of the studies [26, 29]. Despite positive change for the intervention groups in all three studies, none of these demonstrated significant between group differences.

A number of measurement scales used in the trials were not incorporated in the outcome data for the review as they were not validated scales: Step test [23, 32], Functional reach test [20], physical activity scale in individuals with physical disability [28] and short physical performance battery [29]. Eight of the 14 included RCTs [19-23, 26-29] used a combination of ordinal and ratio scales of measurement. They all had established psychometric properties with all but one study identifying MCIDs in ratio data (Hart et al., 2004). A common reason for this lack of evidence could be from the potential lack of statistical power due to small sample sizes. This would be more practical and realistic in clinical practice and should be considered in the evaluation of small group interventions with complex mechanisms for change [34, 35].

Please insert table 4 here.

Measurement of Intensity Mechanisms

None of the studies used intensity as a primary outcome measure although five studies discussed how class difficulty and intensity was used to progress the intervention [21, 24, 26, 27, 32]. One study used guidelines from the Royal College Sports Medicine guidelines [32] demonstrating an improvement between groups, over time and at long term follow up for the 6MWT with MCIDs reported. Two groups used maximal heart testing to guide intensity although this was only used in the control group [24] and the other did not mention progression to exercise complexity or variety [26]. The other studies [21, 36] used exercise instructor judgment to progress exercises as they felt appropriate and failed to demonstrate improvement differences compared to the control groups. Three studies demonstrated significant long-term improvement to 6MWT [32] and RMI [22, 27] two of which [27, 32] were based on a circuit style intervention with progressions to exercises and intensity. The exercise instructor progressed the exercise difficulty based on the individual's performance and improvements to ensure the stimulus was challenging [27]. This demonstrates a lack of consistency for measuring intensity which highlights the need for a standardised method to be adopted.

Discussion

This review set out to answer the questions "how effective are group exercise interventions for improving activity and participation in adult stroke survivors". The review found that when using an exercise intervention in a group setting, activity and participation changes occur, but the changes are inconsistent between different intervention types, delivery method and environment. It was also unclear if these changes were significant at changing activity or participation in ambulatory stroke survivors. Following exclusions, outcome measure assessment and quality assessment of RCT's, 14 studies were included (See table 4). The results of the 14 RCTs were not combined for a meta-analysis because of the varied types of data within the primary outcome measures. It would also be difficult to make accurate comparisons across the included outcome measures in this systematic review as there were a wide variety of activity and participation outcome measures used across the 14 studies.

Recent systematic reviews have demonstrated that exercise interventions in group formats can change cardiovascular fitness but it does not always change impairment, activities of daily living or quality of life [37]. The more functional in nature the exercise intervention the more significant the improvement will be to that functional task, such as walking interventions [7]. They also fail to identify how progression can be utilised through training intensity, loads, volume and variation of exercises to create longer term changes to physical performance and activity.

As described fully in the quality assessment section of this paper review, two papers [18, 19] were unclear in their risk of bias, the remaining were low risk. The level of bias therefore does not appear to impact on the outcome of group-based exercise interventions. The psychometric properties of the measurement scales were clear in nine of the fourteen RCTs and all except one [19] described MICD in the TUG and 6MWT however, the change was always statistically significant. This suggests other mechanisms resulting in the variation to changes of activity and participation such as intensity, variation, specificity and the development of self-efficacy may be responsible.

Intensity

Evidence suggests that high-intensity training when combined with functional strength training it can improve activity after stroke [38]. This can result in reductions in functional limitations and disability as well as supporting the role of neuroplasticity and motor learning [39]. It is unclear if the intensity delivered within these sessions was sufficient, progressed appropriately and challenging enough to create an appropriate stimulus to create positive changes in activity and participation in daily activities [22, 27]. The interventions included in this review did not individually meet the recommended dosage guidelines of 45 minutes per day [40] and it is unclear what, if any, further rehabilitation was carried out by the participants within the studies. Therefore, the intensity and the dosage may not have been sufficient to cause change.

This systematic review provides an overview of group intervention and their effectiveness on activity and participation outcomes. Despite small sample sizes and a general low risk of bias, the findings support positive change to physical activity performance although only in the first few months of intervention.

A RCT aims to control conditions for each arm of the study frequency aggregating data to provide mean values for analysis. Despite ambulatory stroke survivors sharing some similar physical impairment, movement strategy and movement behaviour issues, the recovery of activity and participation varies. It would appear the current interventions reviewed may not provide a sufficient continuous stimulus to change physical performance after the initial few months. Integrating a Realist Evaluation approach with an understanding of evaluating complex interventions [35] into a RCT design may be appropriate when evaluating a group exercise intervention based on evidence based high intensity function strength training with constant variation. There is a need to identify the appropriate outcome measure for the target group to be able to demonstrate meaningful change to activity performance and the self-efficacy to improve everyday life participation in potentially small sample sizes.

Study limitations

This review excluded studies that could have been group exercise but were not carried out using a variety of exercises. However, we focused on only including those with variety as this is representative of community post-stroke exercise groups rather than exploratory interventions. We also excluded 13 studies that may have been a group exercise intervention, but this could not be confirmed due to no response from the authors. In addition, two studies did not report key elements of the risk of bias reporting. This does not suggest these were not carried out appropriately in the respective studies, more these processes were not adequately reported.

Conclusions

This review found that the evidence suggests short term improvements with group exercise interventions are apparent, however, the degree of improvement is within the first 4-6 weeks but less evident at long term follow up with little improvements in participation occurring after six months. This review has highlighted an inconsistency into the measurement and use of intensity to evaluate group training interventions which may be a key mechanism for long-term activity improvements. It has also challenged the appropriateness of large size RCT's to capture the additional benefits gained from group interaction and social support that may facilitate changes to participation in the future. Where RCT methodologies attempt to control confounding variables, this is challenging when evaluating the effectiveness of complex intervention such as group exercise. This is for a number of reasons including the complexity of the stroke population, which is difficult to account for within an RCT design. Therefore, evaluation methodologies such as Realist Evaluation (RE) could be adopted in the future to account for the context by which an intervention is delivered in, which RCTs do not account for. Further research should consider the consistency of measurement and the use of and alternative methodologies to explore the mechanisms underpinning complex interventions.

Conflict of Interest Statement

The Authors declare that there is no conflict of interest.

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Figure 1: Selection process of articles for review

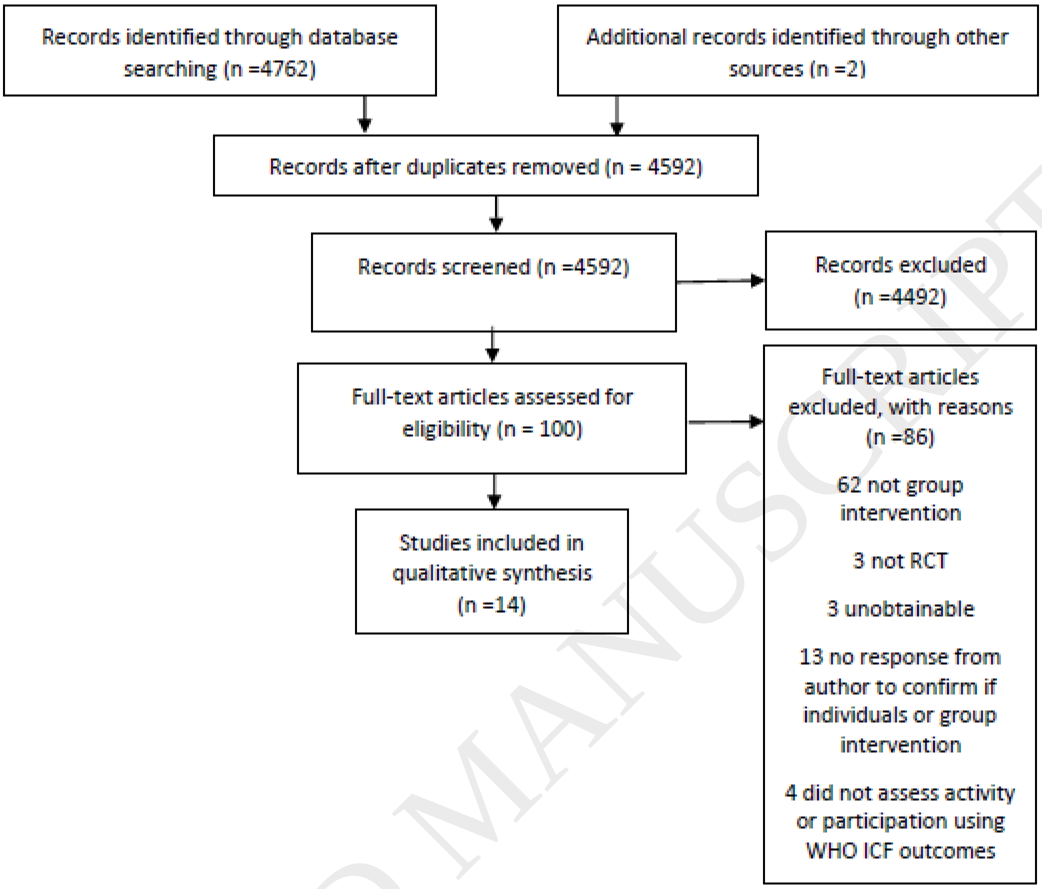

Table 1. Inclusion/exclusion criteria

Inclusion criteria	Exclusion criteria
English language articles Studies reporting an RCT* Studies recruiting adults (18 years+) Group interventions Studies evaluating mixed exercise intervention effectiveness Studies evaluating individuals at least 6 months post stroke (sub-acute, chronic) Studies measuring activity and participation as classified by the World Health Organisation ICF**.	Studies not reporting a RCT Studies involving participants under the age of 18 years Studies evaluating one-to-one sessions Studies evaluating home exercise Studies evaluating technology-based intervention Studies using specific interventions such as walking only, treadmill only, cycle only, vibration and upper limb only. Studies not measuring activity and participation as classified by the World Health Organisation ICF.

*RCT: Randomized controlled trial.

**ICF: International Classification of Functioning, Disability and Health

Table 2. Outcome measures included in this review broken down by Activity and Participation domains.

Activity outcome measures	**Participation outcome measures**
Timed up and go (TUG) test	Stroke Impact Scale (SIS)
6-minute walk test (6MWT)	Nottingham Health Profile (NHP)
Motor assessment scale upper limb- arm (MAS- arm)	Medical outcomes study 36-item short form questionnaire, version 2 (SF36)
Motor assessment scale upper limb- hand (MAS- hand)	
Wolf motor function test (WMFT)	
Frenchay Activities Index (FAI)	
Rivermead Mobility Index (RMI)	
Functional Independence Measure (FIM)	
Berg Balance Scale (BBS)	

Table 3. Risk bias summary

	Random Sequence generation	Allocation Concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Overall
Au-Yeung, 2009 [18]	Low risk	Unclear	High risk	Unclear	High risk	Low risk	Unclear
Blennerhasset, 2004 [23]	Low risk	Low risk	High	Low risk	Low risk	Low risk	Low
Chu et. al, 2004 [24]	Low risk	Low risk	High risk	Unclear	Low risk	Low risk	Low
Dean, 2012 [32]	Low risk	Unclear	High risk	Low risk	Low risk	Low risk	Low
Harrington, 2010 [20]	Low risk	Low risk	High risk	Low risk	High risk	Low risk	Low
Hart et. al, 2004 [19]	Unclear	Unclear	Unclear	Low risk	Unclear	Low risk	Unclear
Marigold et. al, 2005 [21]	Low risk	Low risk	Low risk	Low risk	High risk	Low risk	Low
Marsdon et al, 2010 [25]	Low risk	Unclear	High risk	Low risk	Low risk	Low risk	Low
Moore, 2015 [26]	Low risk	Low risk	High risk	Low risk	Unclear	Low risk	Low
Mudge et. al, 2009 [27]	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low
Noh et. al, 2008 [22]	Low risk	Low risk	High risk	Low risk	High risk	Low risk	Low
Pang et. al, 2005 [28]	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low
Taylor et. al, 2014 [29]	Unclear	Low risk	High risk	Low risk	Low risk	Low risk	Low
Vahlberg et, al, 2017 [30]	Low risk	Low risk	Unclear	Low risk	Low risk	Low risk	Low

Table 4: Results summary table.

Author(s), Year, Country, Study design, intervention, frequency and provider	**Number recruited (N) and final follow up (n)**	**Gender M:F, mean age (years), Hemisphere stroke Ratio L:R, mean time since stroke (months)**	**Activity and Participation outcome measures**	**Activity and participation outcome results summary and reported *P* values**	**Use of intensity as measure/method for class progression and intervention type.**
Au-Yeung, 2009 China (Hong Kong) Single blinded, RCT, 1 hour Tai Chi (intervention) or breathing and stretching exercises (control) in day care centres and 3 hours independent practice per week for 12 weeks, physiotherapist qualified to teach tai chi [18]	N (n)= 124 (114) Intervention N= 64 (55) control N= 62 (59)	Intervention: 33:26, 62 (+/- 11), 31:28 and 54 +/- 79 Control: 33, 66 (+/- 10.7), 25:30 and 64 +/- 106	Timed up and go (TUG)	Intervention group improved from 25 +/- 19 to 23 +/- 20 seconds at week 12, and 21 +/- 14 at week 18. The control group improved from 29 +/- 22 seconds to 27 +/- 23 at week 12 and then 27.5 +/- 23 at week 18. Difference between groups (P=0.106) at 12 weeks and P=0.222 at 18 weeks	No intensity measure as part of progressing intervention. Thai Chi intervention
Blennerhassett & Dite, 2004 Australia prospective, randomised, single blinded controlled trial, upper limb (control) or mobility circuit group (intervention) 1 hour daily, 5 days per week for 4 weeks, physiotherapy	N (n)= 30 (30) Mobility N= 15 (15) Upper limb group N=15 (15)	Mobility group: 8:7, 54 (+/- 20), 8:7 and 36 (+/- 25) Upper limb group: 9:6, 56 (+/- 10.5), 9:6 and 50 (+/- 49.2)	6-minute walk test (6MWT), TUG, Motor assessment scale (MAS) upper limb and MAS hand	Mobility group at improved in the 6MWT from 183 meters to 404 at 4 weeks (P<0.001) and 416 meters at 6 months (P=0.19). TUG improved from 24.3 to 12 at 4 weeks (P<0.001) and further improved to	No intensity measure as part of progressing intervention. General mobility circuit and seated upper limb circuit style class

department staff member [23]				11 at 6 months. MAS upper limb and hand average results were unchanged. Upper limb group improved 6MWT from 181 to 288 at 4 weeks (P<0.001) and 313 at 6 months. The TUG also improved from 25.3 to 19 (P<0.006). Changes to MAS upper average score increased by 1 at 4 weeks (P<0.001) at 4 weeks and (P=0.004) at 6 months.	
Chu, 2004 Canada Single blinded RCT, water based exercise class for 1 hour, 3 times a week for 8 weeks (intervention) seated arm and hand exercises (control), physiotherapist and 2 exercise physiologists [24]	N (n)= 12 (12) Intervention N= 7 (7) and control N=5 (5)	Intervention: 6:1, 62 (+/-9), 4:3 and 36 (+/-24) Control: 5:0, 63 (+/- 8), 3:2 and 50 (+/- 25)	Berg Balance Scale (BBS)	Intervention group improved from 52 +/- 5 to 52 +/- 3. The control group improved more so from 50 +/- 4 to 53 +/- 4). Both were near significance at (P=0.094) and were close to the ceiling score of 56.	Target heart rates used to progress intervention in water based- group only. Water based circuit class
Dean, 2012 Australia Prospective, multi centred, parallel single blinded controlled trial, exercise group to improve mobility and physical activity	N (n)= 151 (133) Intervention N= 76 (65) and control N= 75 (68)	Intervention: 38:38, 67 (+/-14), 42:34 and 80 (+/- 80.4) Control: 40:35, 68 (+/- 10.2),	6MWT and TUG	Intervention group walked average 24m further in the 6MWT than the control group (P=<0.001).	Difficulty increased regularly using guidance from ACSM (American College of Sports Medicine):

(intervention), control exercise group to improve upper limb function, weekly for 40 weeks over a one year period, physiotherapist. [32]		47:28 and 62 (+/- 65)		The group was divided into fast and slow group walkers (cut off 0.8m/s), with fast walkers walking 49 meters further (P<0.001) than the control fast walkers. The slow walkers in the intervention group walked 17 meters further than the slow walkers in the control group (P=0.7). TUG (P=0.21) in either group but a MCID of 5.1 s was reported between groups at 12 months	
Harrington, 2010 UK Single blinded, parallel, RCT, exercise/education schemes twice weekly for eight weeks in leisure and community centres (intervention, standard care (control), volunteers, qualified exercise instructors supervised by a physiotherapist [20]	N (n)= 243 (228 at 9 weeks and 205 at 6 months) Intervention N 228 (109 and 97) and Control 124(119 and 108)	Intervention: 65:54 and 71 (+/- 10.5), 41:58 Control: 67:57, 70 (+/- 10.2), 47:57 Average time from stroke was aggregated for both groups 10 (Range 5.4-17.1)	Rivermeed Mobility Index (RMI), Frenchay Activity Index, TUG	The intervention group TUG improved at both 9 weeks (1.4 seconds quicker) and 6 months (2/3 seconds quicker) (P<0.01) for both. The Intervention group improved the Frenchay Activity Index by 1.5 at 9 weeks and 1.5 again at 6 months (P<0.01) for both. The control group improved by 1 second at 9 weeks and 1.5	No intensity measure as part of progressing intervention Circuit class set up. Progression based on instructor's preference.

				seconds at 6 months (P<0.01) and (P<0.05) respectively. The control group improved the FAI by 1 at both 9 weeks and 1 at 6 months (P<0.05) for both RMI in both control and intervention showed no significant changes.	
Hart, 2004, Israel, RCT, tai chi (intervention), certified tai chi instructor and physiotherapy (control) for 1 hour twice weekly for 12 weeks, physiotherapist [19].	N = 18 Thai chi N=9 and control N=9 (n not given)	Thai Chi: 8:1, 61 (+/- 5), 5:4 Control: 8:1, 57 (+/- 7), 5:4 Average time from stroke was aggregated for both groups 27 (range 13-54)	BBS and TUG	The Thai Chi group did not demonstrate any significance changes with BBS but increased TUG (P=0.025). The control group did improve BBS (P=0.01). Full results tables were not available to see actual change values.	No intensity measure as part of progressing intervention. Thai Chi intervention
Marigold, 2005 USA Blinded RCT, agility or stretching and weight lifting group 3 times a week for 10 weeks at a community centre, physical therapist, kinesiologist and a recreation therapist [21]	N (n)= 61 (48) Agility N= 30 (22) and Stretch/weight shift (S/WS) N= 31(26)	Agility: 17:5, 68 (+/- 9), 10:11 and 43 (+/- 22) S/WS: 18:8, 68 (+/- 7.2), 8:18 and 46 (+/- 29)	BBS, TUG, NHP	Agility group improved TUG by 3.5 seconds achieving significance of (P=0.007). BBS improved from 45 to 48 and NHP improved from 116 to 99 although these changes were not significant. S/WS group achieved TUG by 0.5 seconds, BBS improved from 18	Agility group only discussed progression with difficulty based on individual's performance. No use Objective measure for intensity.

				to 17 and NHP improved from 155 to 123. None of these were significant. No improvements were made in either group at a follow up review.	
Marsdon, 2010, Australia, crossover RCT, circuit class once a week for 7 weeks at local public hospital. Control group crossed over to intervention group, physiotherapist, social worker, dietician, clinical nurse, consultant, speech pathologist, occupational therapist. [25]	N (n) = 26(24), Intervention N=12 (11), control N=14(13).	Intervention 10:2, 70, 3:8, 37:2. Control: 9:4, 73.1, 5:5, 39.	6MWT, TUG	No significant between group differences observed.	No intensity measure reported.
Moore, 2015 UK Single centre, single blinded parallel RCT, community based exercise (intervention) or stretching (control) group 3 times a week for 19 weeks, physiotherapist and a physical activity instructor. [26]	N (n)= 40 (40) Exercise N=20 (20) and control N=20 (20)	Exercise: 18:2, (68+/-8), 9:10 (1 bilateral) and 21 (+/- 34) Stretch: 16:4, 70 (+/- 11), 7:9 (2 bilateral) and 16 (+/- 12)	BBS, 6MWT, Stroke Impact Scale (SIS)	Exercise group improved 6MWT with an average change of 85meters (P<0.01). BBS improved by an average of 5 points (p<0.01). SIS physical total increased by 16 (P=0.03) Control group improved by an average of 22m (P=0.02). BBS improved by an average of 2 (P=0.04). SIS physical	Using MHR to measure and progress intensity. Little mention of progression of exercise in other methods. Circuit class set up

				total increased by 12 with although with a significance of P=0.10.	
Mudge, 2009 New Zealand Single blinded RCT, circuit group 3 times a week for 12 weeks (intervention) and 8 90 minute sessions of a social/educational class (control), one investigator and 2 physiotherapy students. [27]	N (n)= 58 (54) Intervention N= 31 (31) and control N=27 (23)	Intervention: 19:12, 76 (range 39-89), 11:20 and 40 (range 6-160) Control: 13:14, 71 (44-86), 12:14 (1x brain stem) and 70 (range 6-224)	6MWT and RMI	Intervention group increased 6MWT by 19 meters (P=0.03). RMI did not achieve an average score change but an improvement with the range of scores achieved a significance of P=0.121 post intervention and (P=0.025) at 3/13 follow up. Control group reduced the average distance in the 6MWT by 1 meter. RMI demonstrated minimal and non-significant changes.	No intensity measure as part of progressing intervention. Circuit class set up. intensity Progression via increasing exercise difficulty
Noh, 2008 Korea Randomised controlled pilot trial, aquatic therapy group in a therapeutic pool (intervention), conventional therapy (control) for 1 hour, 3 times a week for 8 weeks, therapist. [22]	N (n)= 25 (20) Intervention N= 13 (10) and Control N= 12 (10)	Intervention: 7:6, 61.9 (+/- 10.1), 7:6 and 33.6 (+/- 46) Control: 5:7, 66 (+/- 11.4), 5:7 and 19 (+/- 20)	BBS, MAS	Intervention group improved BBS score by average change of 8 points (P<0.05). MAS for the intervention group improved from 3 to 5 out of total score of 6 (P<0.05). Control group improved BBS by 2. The MAS demonstrated a smaller	No intensity measure as part of progressing intervention. Aquatic therapy intervention based on a form of thai chi movements.

				increase improving from 3.5 to 4.1 out of a total of 6 achieving a significance of (P<0.05).	
Pang, 2005 Canada Prospective, single blinded RCT intervention, fitness and mobility exercises ("FAME" intervention), seated upper extremity programme (control) for 1 hour, 3 times a week for 19 weeks in a community hall, physical therapist, occupational therapist, exercise instructor [28]	N (n) = 63 (60) Intervention N=32 (30) and control N=31 (30)	Intervention: 19:13, 66 (+/- 19), 19:13 and 62 (+/- 60) Control: 18:13, 65 (+/- 8), 22:9 and 61 (+/- 43)	BBS and 6MWT	6MWT improved in intervention group by an average 65 meters (P=0.025). BBS results were improved by 3 points (P=0.01). 6MWT in the control group average an increase of 38m (P=0.025), no significant changes with BBS. Drop outs had significantly higher BBS and 6MWT. Results for BBS were close to ceiling of measure.	Progression using HR % for cycle ergonometry and guidelines from American College Sports medicine on exercise progression.
Taylor-Piliae, 2014 America 3 armed, single blinded RCT, Tai chi at an outpatient rehabilitation centre, tai chi practitioner (intervention) or usual care (control) 1 hour, 3 times a week for 12 week, certified fitness instructor [29]	N (n)= 145 (140) Thai chi 53 (48), exercise 44 (44) and Usual Care 48 (48)	Thai Chi: 24:19, 72 (+/- 10), 14:18 and 39 (+/- 40) Exercise: 20:24, 70 (+/- 9), 15:25 and 33 (+/-59) UC: 23:25, 68 (+/- 10), 14:20, and 39 (+/- 47)	Medical Short Form- 36 (SF36)	Thai Chi group demonstrated significant changes of 1 in physical composite score (PCS) and 3 in the mental composite scores (MCS). Exercise group demonstrated a 1 increase in PCS and 0.3 in MCS.	No intensity measure as part of progressing intervention. Thai Chi intervention

				Usual care group demonstrated a 2 increase in PCS and 4 in MCS. Significance for the changes made in all groups were P=0.04 for PCS and P<0.01 for the MCS.	
Vahlberg, 2017, Sweden, single blinded RCT, progressive resistance and balance exercise programme twice weekly for 3 months (intervention), physiotherapist and one assistant or usual care (control). [30]	N (n) = 43 (43) Intervention N=20(20), control = 23(23)	Intervention 17:3, 72.7, hemisphere stroke not reported, 14. Control: 16:7, 73.7, hemisphere stroke not reported, 14.	BBS, 6MWT	Significant difference between groups observed in 6MWT (P=0.039).	The Borg Rating of Perceived Exertion Scale used to measure intensity.