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Group Circuit Class Therapy for Stroke Survivors – A Review of the Evidence and Clinical Implications

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1. Introduction

Concerns about rising costs of health care are felt by health care professionals around the world (Rosen & Karlberg 2002; Bovier et al., 2005; Robertson et al., 2011) leading to pressure to deliver services in the most cost effective way possible. As new diagnostic tests, surgical procedures or more effective drugs are developed, there is, at least in developed countries, an imperative to make these things available to all, inevitably at an increased cost to the system. This places a downward pressure on all aspects of the health care system to deliver services for the most efficient means to counteract this increased cost. In the case of physiotherapists providing rehabilitation therapy to people who have suffered a stroke, there is an expectation that the current standard of therapy provision will remain stable or in fact be enhanced, with the same or less funding. At the same time, research evidence suggests that providing more therapy time - maximising the time stroke survivors spend in active task practice each day - will maximise their functional outcomes (Kwakkel et al., 2004). So therapists are being asked to do more with less on a daily basis.

Usual practice for stroke rehabilitation around the world for the past several decades has been the provision of therapy in individual, one-to-one therapy sessions. However, group circuit class therapy is an alternate method of therapy service delivery. One study showed that providing physiotherapy in circuit classes rather than in individual therapy sessions led to a significant increase in therapy time without increasing cost (English et al., 2007). While group circuit class therapy for stroke survivors is often touted as 'novel' - there is nothing particularly new or unusual about the concept of providing therapy to groups of people. In the research literature, the first paper written about group circuit class therapy was published by Dean et al in 2000. This small pilot study was the first to describe the effectiveness of group circuit class therapy with regard to improved motor function in people after stroke. Since that time the evidence base has continued to grow and there are now two published systematic reviews on the topic (English, et al., 2007; Wevers et al., 2009).

So what is group circuit class therapy exactly? What are the theoretical underpinnings to this mode of therapy service delivery? What exactly is the current evidence base for group circuit class therapy and where do the gaps exist? This chapter will provide some answers to these questions, as well as providing tools for clinicians who may be interested in implementing this form of therapy delivery.

2. What is circuit class therapy?

Circuit class therapy, in its most basic interpretation, is progressive task-specific therapy provided in a group setting, as opposed to therapy provided with a one therapist to one patient ratio. As it is a relatively new concept in stroke rehabilitation, there is as yet no consensus opinion regarding the definition of circuit class therapy. The only published, specific description of circuit class therapy states: "circuit class therapy is therapy (that is) provided to more than 2 participants, involving a tailored intervention program with a focus on practice of functional tasks received within a group setting, provided to participants with similar or different degrees of functional ability and involving a staff to patient ration of no greater than 1:3" (English, et al., 2007).

Other authors have described circuit class therapy as:

- "Training, organized in a circuit with a series of workstations designed to strengthen affected muscles and provide the opportunity for task practice" (Dean et al., 2000).
- "A mode of exercise training using a series of systematically progressed workstations" (Rose et al., 2010)
- "A model of therapy delivery that utilizes active exercises and activities which are task-specific (practicing the functional task itself or parts thereof) and is provided in an intensive manner. The key components of circuit class therapy are that therapy is provided in a group setting with more than 2 participants per therapist and there is a focus on repetitive practice of functional tasks and continual progression of exercises" (English & Hillier, 2010).

Therefore, circuit class therapy is:

- *Not* recipe driven or one size fits all approach
- *Does* include tailoring and progression of exercises to suit individual participants
- *Does* include one-on-one time with individual participants
- *Does* allow for correction of movement patterns/quality of movement
- *Does* include variety in practice

The group nature of circuit class therapy is integral to the concept, as it is the mechanism by which potential cost savings can be made. However, several researchers have described implementation of circuit class therapy with a one staff member to one participant ratio (Salbach et al., 2004; Yang et al., 2006; Rose et al., 2010). In these cases participants rotated through a program of progressive, task-specific exercises, but rather than performing the exercises independently or under distant supervision, participants were under the constant supervision of a therapist. In the interests of inclusiveness these studies will be discussed in this chapter. To highlight the importance of the group nature of circuit classes, and to avoid any confusion between circuit training in individual sessions and circuit class therapy provided in a group setting, we will refer to group circuit class therapy throughout this chapter.

While group therapy can be used for a variety of aims, including improving speech and language (Simmons-Mackie & Elman 2011) or providing education (Mudge et al., 2009; Harrington et al., 2010; Marsden et al., 2010), this chapter is devoted to the concept of using circuit class therapy for improving motor function. This can include motor function of the arm or leg; however the majority of research to date has focused on outcomes relating to leg function, such as standing balance and walking.

2.1 Who can deliver group circuit class therapy?

To date, the majority of studies investigating the effectiveness of group circuit class therapy have involved physiotherapists delivering or overseeing the implementation of the therapy sessions. However, there is no reason why other professionals with exercise or movement-based training cannot also deliver group circuit class therapy. Health professionals who deliver exercise or movement based therapy include physiotherapists, occupational therapists, exercise physiologists, sports therapists and people trained as assistants or aides to these professions. The roles these professionals play can differ from country to country, or even within countries and between different hospitals or rehabilitation centres within the same city or area. For example in some settings in Australia the role of providing arm therapy sits solely with occupational therapists, whereas in other settings it is shared between physiotherapists and occupational therapists. While there is no evidence as to which health profession may be better able to provide group circuit class therapy, it is essential that the therapist has the skills and qualifications to be able to clinically reason the issues the stroke survivor is having with his/her mobility, design appropriate exercises to address those issues and be able to progress, update and modify the prescribed exercise program. In order to do this effectively, the therapist must also have a detailed understanding of the clinical condition of stroke.

2.2 In what settings can group circuit class therapy be delivered?

Group circuit class therapy can be delivered by a variety of health professionals, and it can also be delivered in a variety of settings. In this chapter, inpatient settings refer to both acute and rehabilitation hospitals in which patients spend the majority of their days and nights, with the exception of day leave or overnight leave. Outpatient settings refer to sites where therapy is provided to people who are living at home or elsewhere. We have chosen to define periods of time post stroke as either 'early' (less than 6 months since stroke onset) or 'late' (6 months or more post stroke onset).

Group circuit class therapy provided early after stroke

The majority of people who have a stroke are admitted to an acute hospital. There is one published paper reporting on the use of group circuit class therapy for people in acute hospitals. Zanker et al., (2007) reported on the feasibility and sustainability of group circuit class therapy provided to people with mixed diagnoses on a stroke, aged care and neurological ward in an acute hospital in Australia. In a more recent study, Rose et al (2010) described the implementation of circuit class therapy for people very early (on average 10-11 days) after stroke, but these sessions were provided with a participant to staff ratio of 1:1. Table 1 summarises published papers reporting on the use of group circuit class therapy in the acute hospital setting including the reported aims of the classes, types of participants included and the duration and frequency of classes.

Author	Country	Aims of classes	Duration and frequency	Diagnoses of participants (mean time since stroke in days)	Participant mix (minimum level of functional ability)
Zanker et al 2007	Australia	Increasing activity. Mix of mobility related activities and arm activities	Twice weekly, 40-50 minutes per session	Stroke and other neurological disorders and elderly medical patients with physical deconditioning	Sufficient sitting balance to sit in a wheelchair for at least one hour. Able to follow simple instructions.
Rose et al 2010	United States of America	Improving mobility	One 60 minute CCT session and one 30 minute individual session, five days a week	Stroke (10)	Able to follow simple commands.

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Table 1. Details of published papers describing circuit class therapy provided in acute hospital settings.

Therefore, while group circuit class therapy can theoretically be provided to people in acute hospital settings very early after stroke, and there are anecdotal reports of this occurring, there is only two published studies supporting its use in this context. This may be due to the additional barriers to providing group therapy in this setting, such as patient drowsiness precluding tolerance of longer therapy sessions, competing appointments for requisite medical investigations and other therapies, difficulties finding adequate space for the therapy, as well as difficulties transporting patients to and from the therapy area.

Following a period in an acute hospital that may last anywhere between a few days and several weeks, there are, broadly speaking, two primary models of providing rehabilitation care to people within the first month or two following stroke. In many places in Australia, New Zealand and Europe, people stay as inpatients in rehabilitation wards where they receive daily, multi-disciplinary therapy. The length of time people stay in rehabilitation hospitals varies between one week and one, two or several months. Other models of care include early supported discharge where people go home very early after stroke, and receive therapy either in their own homes or at outpatient therapy centres some or all days of the week. Furthermore, in some countries bouts of intensive, inpatient therapy is offered to people months or years later after stroke. Group circuit class therapy can be implemented in all of these scenarios, with the exception of rehabilitation in the home (where group therapy is not possible).

During this early, intensive rehabilitation period, group circuit class therapy can be delivered as either an adjunct to usual care therapy, or as the sole method of therapy service delivery. There are three published studies investigating the use of circuit class therapy in this early rehabilitation phase, and another, as yet unpublished trial (van de Port et al., 2009). Table 2 summarises the key elements of group circuit class therapy as defined in these papers.

These papers describe quite distinct models of providing group circuit class therapy. The trial by English et al (2007) investigated the use of group circuit class therapy as the sole method of physiotherapy service delivery to people receiving inpatient rehabilitation after stroke. Compared to the other group circuit class therapy trials, the exercises and structure of the classes in this trial were less strictly defined. The classes were tailored to address multiple aims including arm therapy, and included participants with a range of levels of ability, not just those who were able to walk independently. Therefore, rather than rotating around a set number of pre-determined 'stations', participants undertook their own individualised exercise program within a group setting. Classes also included group activities and activities in pairs.

In the two other published trials conducted in an inpatient rehabilitation setting for people within the first 6 months of stroke, (Blennerhassett & Dite 2004; Outermans et al., 2010) participants were offered daily group circuit class therapy sessions in addition to usual care therapy. In both of these trials participants were required to walk independently to be eligible for inclusion and the structure of the classes was more formally defined. Details of the content of therapy provided in this and other published group circuit class therapy trials is outlined in Section 2.5. In the trial by Blennerhassett & Dite (2004), participants were randomised to receive either group circuit class therapy sessions aimed at improving mobility and balance, or group circuit class therapy aimed at improving arm function. All participants in the trial by Outermans et al (2010) received group circuit class therapy aimed at improving walking and walking-related function, with the difference between groups being the intensity of exercise.

Author	Country	Aims of classes	Duration and frequency	Diagnoses of participants (mean time since stroke in days)	Participant mix (minimum level of functional ability)	Adjunctive sole m physio delivered
Blennerhasset and Dite 2004	Australia	Improve walking and walking-related function OR arm function	60-minute session, once per day, 5 days a week	Stroke (43)	Walk 10 m without physical assistance	Adjunctive
English et al 2007	Australia	Improve walking and walking-related function AND arm function	90-minute sessions twice daily, 5 days a week	Stroke (39)	Able to sit unsupported	Sole
van de Port et al 2009	Netherlands	Improve walking and walking-related function	90-minute session twice a week for 12 weeks	Stroke (not known)	Walk 10 m without physical assistance	Sole
Outermans et al 2010	Germany	Improve walking and walking-related function	45-minute sessions 3 times a week for 4 weeks	Stroke (23)	Walk 10 m without physical assistance	Adjunctive

Table 2. Details of published papers describing circuit class therapy provided early after stroke in settings other than acute hospitals.

The other trial conducted in the early rehabilitation period was the FIT-Stroke trial recently completed in the Netherlands (van de Port, 2009). In this study, participants were recruited on completion of their inpatient rehabilitation if they were less than six months post-stroke and were able to walk independently. Participants attended an outpatient setting twice a week and received group circuit class therapy as the sole method physiotherapy service delivery, with the exception that arm therapy was also provided to some participants outside the group circuit class therapy sessions.

Group circuit class therapy provided later after stroke

The majority of group circuit class therapy trials have been conducted with participants later (typically at least six months, and up to several years) post stroke. It is this group of trials that provide the greatest evidence for the effectiveness of group circuit class therapy for people after stroke. Most papers describe group circuit class therapy being provided with the primary aim of improving mobility while the control group received either 'sham' therapy, or 'usual care' therapy. The trial by Pang et al (Pang et al., 2005; Pang et al., 2006) compared people receiving either circuit class therapy aimed at mobility or at improving arm function. However, the inclusion criteria for the trial (independent walking ability and ability to raise heart rate to at least 60% of maximum heart rate) suggested that the primary research question was centred upon mobility, as there was no inclusion criterion related to arm function. The settings in which group circuit class therapy was conducted included local community halls, local hospitals and rehabilitation centres. Table 3 describes the key elements of these papers.

It is clear that the majority of trials of group circuit class therapy have included participants several months after their stroke. In these trials, circuit class therapy was provided one to three times a week for between four and 19 weeks. The staff to patient ratio ranged from 1:1 to up to seven participants per therapist (Mead et al., 2007). With the exception of two trials (Harrington et al., 2010; Marsden et al., 2010), participants in all trials were able to walk independently at enrolment. All trials indicated that group circuit class therapy was being provided with the intent to improve walking ability, although additional aims including balance, community reintegration and arm function were mentioned in some of the trials. All trials reported positive outcomes for at least some of the outcomes measured. An in-depth reporting of the evidence base for group circuit class therapy based on all published trials is reported in Section 2.4.

2.3 What are the theoretical underpinnings of group circuit class therapy?

It is well established that active and repetitive practice of movement is required to maximise neuroplasticity after stroke. Furthermore, physical activity is vital to general health and has been shown to reduce the risk of all stroke types (Lee et al., 2003). This section will review what is known about the levels of physical activity in people both early and later after stroke, and will present current knowledge regarding neuroplasticity and motor learning as it pertains to group circuit class therapy. There are two themes to this section – maximising physical activity to improve health and maximising neuroplasticity and recovery of function after stroke.

Author	Country	Aims of classes	Duration and frequency	Diagnoses of participants (mean time since stroke in days)	Participant mix (minimum level of functional ability)
Dean, et al., 2000	Canada	Improve walking ability	1 hour 3 times a week for 4 weeks	Stroke (658)	Able to walk 10m independently
Salbach et al., 2004	Canada	Improve walking ability	3 times a week for 6 weeks (duration not stated)	Stroke (228)	Able to walk 10m independently
Pang et al., 2006/2005	Canada	Improve leg function/walking OR improve arm function	60-minute sessions, 3 times a week for 19 weeks	Stroke (1881)	Able to walk 10 m independently, and to raise HR to at least 60% HR max
Marigold et al., 2006	Canada	Improve walking ability and standing balance	1 hour 3 times a week for 10 weeks	Stroke (1351)	Able to walk 10m independently
Yang et al., 2006	Taiwan	Improve leg strength and walking ability	30-minute session 3 times a week for 4 weeks	Stroke (1927)	Able to walk 10m independently
Mead et al., 2007	United Kingdom	Improve cardiovascular fitness and walking ability	75-minute sessions 3 times a week for 12 weeks	Stroke (159)	Able to walk independently (minimum distance not specified)
Mudge et al., 2009	New Zealand	Improve walking ability	3 times a week for 4 weeks	Stroke (1424)	Able to walk 10m independently
Harrington et al., 2010)	United Kingdom	Mobility and community integration	1-hour sessions 2 times a week for 8 weeks (followed by an education session)	Stroke (not reported)	Living in the community
Marsden et al., 2010	Australia	Mobility and community integration	1-hour sessions once a week for 7 weeks (followed by an education session)	Stroke (1159)	Living in the community, have a carer

*personal communication with author
 Table 3. Details of published papers describing circuit class therapy provided later after stroke.

How active are stroke survivors?

A recent systematic review identified 24 studies conducted between 1980 and 2009 which measured activity levels of stroke survivors in hospital (West & Bernhardt 2011). Fifteen of these studies measured patient activity over the whole day and 10 examined the physical activity of people in therapy sessions specifically. Of the studies that examined physical activity levels over the whole day, all used a technique known as behavioural mapping. Behavioural mapping involves participant being observed for a one minute period every 10 minutes and their activities, where they were and who they were with are recorded on a checklist. From this data, the time spent in various levels of physical activity (none, low, moderate to high) is estimated as minutes. Data can also be expressed as a percentage of observations. Participants were observed for the majority of the working day – for example from 7 or 8am in the morning until 5, 6 or even 7pm at night. The authors found that stroke survivors in hospital spent the majority of the day inactive (median 48.1%, inter-quartile range [IQR] 39.6-69.3), and alone (median 53.7%, IQR 44.2%-60.6%) (West & Bernhardt 2011). When only the category of moderate to high physical activity is examined (this includes activities such as standing, walking and using stairs) only a median of 21% (IQR 12.8 to 27.7%) of the day is spent in these activities (West & Bernhardt 2011).

Of the 10 studies examining physical activity levels in therapy sessions, a variety of techniques were used in including behavioural mapping, video-taping and therapist report (West & Bernhardt 2011). Within these studies, participants were reported to be inactive for between 20% and 58% of therapy sessions. A recent study found that therapists systematically overestimate active time by a mean of 28% and underestimate inactive time by a mean of 36% (Kaur 2011). Therefore the validity of relying on therapists' estimates of how much time their clients spend physically active in therapy sessions is questionable. In studies in which used video-taping of therapy sessions to examine content of therapy sessions, participants are reported to be inactive for between 30 and 40% of their therapy sessions (Kaur 2011). Interestingly, the percentage of time spent active appears similar in individual therapy sessions compared to group circuit class therapy sessions (Elson et al., 2009). In a more recent study, again using video footage of therapy sessions, inactive time was higher in group circuit class therapy sessions (37%) compared to individual therapy sessions (28%) (Kaur 2011). The longer duration of group circuit class therapy sessions meant that participants were active for more time in these sessions (mean of 44 minutes compared with 24 minutes in individual therapy sessions). The long periods of inactive time in therapy sessions, coupled with the finding that therapists systematically overestimate active time and underestimate inactive time (Kaur 2011) suggest that therapists should be mindful of maximising the time participants spend active in group circuit class therapy sessions.

Later after stroke, for those people who regain sufficient function to live in their own home, the picture of activity levels remains poor. Table 4 summarises findings from studies of activity levels of people living in the community after stroke. The majority of these studies used objective measures of activity by using accelerometers or pedometers to estimate the number of steps taken each day. While there are known inaccuracies with these measures, as most devices tend to underestimate step counts in people who walk slowly (Taraldsen et al., 2011), the consistent picture is one of very low levels of physical activity. The studies

which measured daily step counts reported they ranged as low as 1400 (Michael & Macko 2007) to 4000 (Fulk et al., 2010) steps per day. The exception was the study by Mudge et al., (2007) which found participants took an average of almost 6000 steps per day. Even so, compared to published norms of 6000 to 8500 steps per day for healthy older adults (Tudor-Locke & Myers 2001), these trials show that people after stroke are generally very inactive.

Therefore, stroke survivors are significantly less active than their non-stroke-affected counterparts. Activity levels are generally poor in the rehabilitation setting and following discharge home, which can have negative flow on effects to general health and well-being. It is known that increasing the amount of activity patients engage in each day is beneficial for their general health, so health care providers should tailor rehabilitation programs to stroke survivors to increase their activity levels. Group circuit class therapy is one method of therapy service delivery which facilitates increased activity.

Author	Country	Participants	Main findings
Michael & Macko 2007	USA	n=79 Able to walk independently	Low step counts (1389±797 per day) and almost none at high intensity (78 ±168 steps per day at >30 steps per minute)
Michael et al., 2005	USA	n = 50 Able to walk independently	Low step counts 2837±1503 per day
Rand et al., 2010	Canada	n=40 Able to walk independently	The range of measured daily energy expenditure was vast and suggested that some participants spent most of the day sitting in a chair while others were relatively active.
Shaughnessy et al., 2005	USA	n = 19 'mild to moderate hemiplegic gait deficits'	Daily step counts 1536±10 at 2 weeks post-discharge from inpatient rehabilitation to the community and 2765±1677 at 3 months after discharge.
Haeuber et al., 2004	USA	n = 17 Able to walk independently	Mean steps per day 3035±1944 (range 400 to 6472).
Fulk, et al., 2010	USA	n = 32 Able to walk independently at a speed of 0.4 m/s or greater	Mean steps per day 3838±1963 versus age matched controls 6294±1768
Mudge, et al., 2007	New Zealand	n= 58 Able to walk independently	Mean steps per day 5719±3453

Table 4. Physical activity levels of community dwelling stroke survivors.

Neuroplasticity

Clinicians working with people after stroke should be aware of the key principles underpinning neuroplasticity in order to assist their patients in maximising motor recovery. Neuroplasticity is a term that refers to the process of the brain remodelling and 'rewiring' new connections in response to experience. It is the mechanism by which the brain learns new behaviours and relearns lost behaviours in response to rehabilitation (Kleim & Jones 2008; Cramer et al., 2011). There is now widespread and robust evidence that the brain is constantly undergoing remodelling in response to experience (Kleim & Jones 2008) and this occurs in the healthy brain (Elbert et al., 1995; Karni et al., 1998; Kolb 2003) as well as the brain affected by neurological damage, including stroke. Several studies have now shown evidence of neuroplastic changes in the brain that correlate with functional recovery after stroke, and more specifically, changes that occur in response to motor therapy (Friel et al., 2000; Johansen-Berg et al., 2002; Green 2003). For a comprehensive overview of neuroplasticity principles as they relate to neurological rehabilitation, see Kleim & Jones (2008).

The fundamental principle that underpins neuroplasticity is 'use it or lose it'. There is now a wealth of evidence that areas of the healthy brain that are used repeatedly, such as the area receiving sensory input from the reading finger of a Braille reader or the fingering hand of a violin player, increase in size and connections in response to the increased sensory input (Pascual-Leone & Torres 1993; Elbert, et al., 1995). Likewise, areas of the healthy brain that are not used, for example when a limb is restrained or amputation occurs, lose function and connections (Cohen et al., 1991; Liepert et al., 1995).

The brain affected by stroke therefore needs to receive repeated, specific sensory input in order to remodel in the most effective way for the stroke survivor's functional recovery. Researchers have now demonstrated that thousands of repetitions of a new task are required to establish changes in the stroke-affected brain (Boyd et al., 2010) and this repetition needs to continue even after functional, behavioural changes are seen for lasting change to occur (Kleim & Jones 2008). Specificity and salience are also important – tasks to be practiced must be specific to the function that is being retrained, and be meaningful and provide reward to the person performing the task. Variety in practice is important to increase skill (Shumway-Cook & Woolacott 2001). When a person performs a task that is too easy, such as repetitive practice of an unskilled movement, it is not likely to provide lasting neuroplastic changes (Kleim et al., 1996; Plautz et al., 2000; Boyd et al., 2010).

Clinically, this means that in order to optimise a stroke survivor's neuroplastic changes and functional recovery, therapeutic exercises should be challenging to the patient, but be tailored so the person can gain reward from performing the exercise. Part-practice and tasks that are as closely related as possible to the new skill being learnt should be prescribed and performed. In addition, patients should practice under slightly different conditions; for example sit to stand using different chairs, reaching using different objects, walking over different surfaces, at different speeds and so on. All tasks should be practiced even after functional and behavioural changes are observed.

New evidence is emerging which suggests that not all practice needs to be active. Mirror neurones in the premotor and parietal cortex have been shown to activate when a person observes a movement as well as when that person performs a movement (Garrison et al.,

2010). In other words, when an action is observed, the brain generates activity that is similar to what occurs when the action is actually performed (Garrison et al., 2010). This is thought to be the mechanism by which observation of movement or actions enhances motor learning. Research into how best to capitalize on this function is in its infancy, but there is evidence that observation of movement in conjunction with actual physical practice improves motor learning (Mattar & Gribble 2005). Observation should be congruent; what is observed should be the same as what is practiced (Garrison et al., 2010). The group nature of group circuit class therapy may be an ideal format to incorporate observation of movement with physical practice.

2.4 What is the evidence for the effectiveness of circuit class therapy for stroke survivors?

Several meta-analyses and subsequent research trials have shown that task-oriented exercises are effective in improving balance, transfers, gait and gait-related activities (such as climbing stairs) in stroke survivors, especially when applied within the first six months post stroke. (Kwakkel et al., 2004; Van Peppen et al., 2004; French et al., 2009; Veerbeek et al., 2011). Recently, two independently conducted meta-analyses (English & Hillier 2010; Wevers et al., 2009) studied the effect of circuit class therapy on walking related outcomes. In total nine trials were included in these two reviews (Salbach et al., 2004; Pang et al., 2005; Marigold et al., 2006; Pang et al., 2006; Yang et al., 2006; Mead et al., 2007; Mudge et al., 2009). One trial was reported in two papers (Pang et al., 2005; Pang et al., 2006). Due to slightly different aims and inclusion criteria, three studies were included in both reviews (Dean et al., 2000; Blennerhassett & Dite 2004; Pang et al., 2005; Pang et al., 2006). The review of Wevers et al (2009) only included randomised controlled trials, whereas the review of English & Hillier (2010) also included non-randomised, controlled clinical trials. In addition, the review by English & Hillier (2010) primarily focussed on studies using the 6 minute walking test as an outcome measure and only included studies in which circuit class therapy was provided in a group setting. Table 5 summarises the key evidence relating to group circuit class therapy effectiveness.

Walking distance

Both meta-analyses showed that circuit class therapy has a positive effect in terms of improving walking distance as measured by the 6 minute walk test. Mean differences of 42.5 meters (Wevers et al., 2009) and 76.6 meters (English & Hillier 2010) were reported. The study by Blennerhassett & Dite (2004), which was conducted in the sub-acute phase after stroke, showed the largest absolute improvement, with a difference of 116m between the intervention and the control group. This difference is greater than the 13% change which has been reported as the minimum clinically relevant change (Flansbjerg et al., 2005; Fulk et al., 2008). Three more studies also showed clinically relevant changes (Salbach et al., 2004; Pang et al., 2005; Mudge et al., 2009). A recent pilot study, published after the meta-analyses, showed that high intensity circuit class therapy resulted in significantly greater walking distances compared to low intensity circuit class therapy, although both groups showed relatively small changes (5-10%) (Outermans et al., 2010).

Walking speed

Positive results were reported for walking speed when comparing circuit class therapy with control interventions (English & Hillier 2010; Wevers et al., 2009). Five included studies

measured walking speed and only the study of (Dean et al., 2000) was included in both meta-analyses. Mean overall improvements were calculated as 0.07 m/s (Wevers et al., 2009) and 0.12 m/s (English & Hillier 2010) following the circuit class therapy interventions. However, as the minimal clinically significant difference in walking speed for people recovering from stroke has been estimated to be 0.16 m/s (Tilson et al., 2010), neither meta-analysis was able to demonstrate that circuit class therapy led to a clinically meaningful difference. Only the studies of (Yang et al., 2006; Mudge et al., 2009), and the pilot study of (Outermans et al., 2010) showed clinically relevant changes in walking speed.

Impairments

Leg muscle strength was reported in three studies. Yang et al (2006) concluded that leg muscle strength (hip, knee and ankle) was significantly improved after individually supervised circuit class therapy compared to no therapy. In line with these results (Pang et al., 2005) reported significantly more gain in paretic leg muscle strength in the circuit class therapy group compared to the control group. In both studies a performance test using a handheld dynamometer was used to determine muscle strength. Mead et al. (2007) also studied leg power but no significant differences between the circuit class therapy group and the control group were found.

Two studies examined oxygen consumption determined by a maximal exercise test (VO_2 max) (Pang et al., 2005) or during walking (VO_2 mL/kg per metre) (Mead et al., 2007). Both trials found benefits related to group circuit class therapy. In the trial by Mead et al (2007), walking economy improved significantly more in the group receiving circuit class therapy compared to the group receiving relaxation therapy while Pang et al (2005) found that participants receiving group circuit class therapy showed significantly more improvement in cardiorespiratory fitness post-intervention, compared to the control group.

Activities and Participation

Evidence regarding the effect of circuit class therapy on improving standing balance is somewhat unclear, which may be in part due to the variety of outcome measures used. The Berg Balance Scale (Salbach et al., 2004; Pang et al., 2005; Marigold et al., 2006; English et al., 2007) and the Timed Up and Go test (Dean et al., 2000; Blennerhassett & Dite 2004; Salbach et al., 2004; Marigold et al., 2006; Yang et al., 2006; Mead et al., 2007; Mudge et al., 2009) were the most common measures used. Both meta-analyses (English & Hillier 2010; Wevers et al., 2009) showed no significant differences for the Berg Balance Scale between the intervention and control groups. In contrast to the meta-analysis by English & Hillier (2010), the meta-analysis of Wevers et al., (2009) showed a significant difference in the Timed Up and Go test between the intervention and the control groups. The patients included in the study of (Blennerhassett & Dite 2004) showed the greatest improvements. The Activities Balance Confidence scale was used in two studies (Marigold et al., 2006; Mudge et al., 2009) included in the meta-analysis by English & Hillier (2010) and showed a significant overall effect. The Step Test was used in two studies (Dean et al., 2000; Blennerhassett & Dite 2004) and showed an overall significant effect in favour of the intervention group (English & Hillier 2010). In the review of Wevers et al., (2009) the study of Yang et al (2006) was included, which also reported step test data. Inclusion of this trial in the meta-analysis led to non-significant findings. One included study used the Functional Reach test and showed no significant differences between the groups (Mead et al., 2007). Results of a more recently

published randomised controlled trial showed no significant differences between groups using the Functional Reach test and the Berg Balance Scale (Outermans et al., 2010).

Several different outcome measures were used to determine participants' abilities to perform activities of daily living. However, no published studies reported significant between group differences on any of the measures.

Of the trials that included mobility outcomes such as the Rivermead Mobility Index (Mead et al., 2007; Mudge et al., 2007) or the Elderly Mobility Scale (Mead et al., 2007), none showed significant improvements related to circuit class therapy. In the study of (English et al., 2007) the degree of physical assistance required to walk was measured by the Iowa Level of Assistance Scale. In this trial, significantly more people who received group circuit class therapy were able to walk independently on discharge from inpatient rehabilitation when compared to those receiving traditional one-to-one therapy.

Service related outcomes

Length of hospital stay was calculated in two studies (Blennerhassett & Dite 2004; English et al., 2007) and although both studies showed trends in favour of the intervention group, no statistically significant differences were found. However, when data were pooled, the difference between the intervention and control group was statistically significant (English & Hillier 2010) and participants receiving group circuit class therapy had a mean length of hospital stay of almost 20 days less than the control group participants.

Most studies reported on falls occurring during the intervention or the whole study period. In the study of (Marigold et al., 2006) patients kept a falls diary. No statistically significant differences were reported between the intervention and the control group. Several studies found that more falls were reported among participants receiving circuit class therapy. English et al., (2007) reported four falls occurred during group circuit class therapy sessions compared to two during usual care (individual therapy sessions), Pang et al., (2005) reported five falls in the circuit class therapy group and one in the control group and Salbach et al., (2004) reported four falls occurring during individually supervised circuit class therapy. All authors reported that none of the falls resulted in injury. Two trials (English et al., 2007; Mead et al., 2007) also examined the differences in the rate of falls outside of therapy sessions with neither reporting any between group differences. Overall, no serious adverse events were reported which suggests that group circuit class therapy is a safe intervention.

Gaps in the evidence

From the studies described above, it can be concluded that circuit class therapy can be an effective method to provide therapy to people following stroke, particularly in relation to improving their walking speed and walking distance. However, several gaps remain in our knowledge regarding the evidence of this approach.

The aspect which makes group circuit class therapy especially attractive, but which has been studied very little, is the cost-effectiveness of the intervention. Since circuit class therapy is provided in groups and patients are not treated with a staff to patient ratio of 1 to 1, this should reduce the costs of the treatment and make group circuit class therapy more cost effective than other therapy interventions. In the study of English et al (2007), six patients

were included in the group circuit class therapy sessions under the supervision of one physical therapist and one assistant, leading to a 1:3 staff to patient ratio. The researchers found that participants receiving the group circuit class therapy received a significantly greater amount of therapy than those stroke survivors receiving traditional one-to-one therapy (129 minutes per day compared to 37 minute per day). Therefore, without changing staffing-associated costs, changing the method of service delivery resulted in substantial increases in therapy time for stroke survivors. In addition to providing more therapy to the patients, group circuit class therapy saved the therapist time – for a therapist to provide group circuit class therapy to six patients it took 129 minutes a day, whereas the amount of therapist time required to provide individual therapy sessions for 6 patients was 222 minutes a day (English et al., 2007).

Economic evaluations include not only the costs of the intervention, but also the costs related to the use of health care facilities (primary and secondary care, community care) social care costs (domestic care, meals on wheels), medication and transport. None of the included studies reported on these sorts of costs. Although not completely comparable, the study of (Harrington et al., 2010) included an economic evaluation when studying the effects of a community-based exercise and education scheme for stroke survivors (Harrington et al., 2010). They concluded that the costs were significantly higher in the intervention group compared to the control group receiving usual care. The reason for the higher costs was unexplained, but the method used to analyse the costs can be implemented in future studies. It is highly important to include cost-effectiveness analysis in future trials, since reduced staff to patient ratios will lead to lower staff-related costs without lowering the amount of therapy, which makes circuit class therapy a very attractive treatment method for the growing stroke population.

When looking at the published papers on group circuit class therapy a few things need to be considered. Most studies included patients who were able to walk and were free of significant cognitive problems or language impairments. It is essential that participants understand the set tasks at each of the workstations, however, with appropriate supervision and instruction, participants with minor cognitive problems and aphasia should be able to participate in group circuit class therapy. Therefore these patients should be included in future research. Likewise, group circuit class therapy can be tailored to suit people with moderate to severe mobility impairments (ie people unable to walk independently), which would allow inclusion of patients earlier after their stroke. In the light of the study by Blennerhassett & Dite (2004), which was conducted in the more acute phase after stroke and showed some of the most positive results from all the trials, it would seem that the early post-stroke period is an appropriate time to provide group circuit class therapy. More research is needed on the effects of group circuit class therapy in the early phase after stroke, for example including patients in acute hospital settings, and especially including patients with mobility, communication and cognitive limitations.

It would be interesting to do further study regarding the content of group circuit class therapy. Most tasks from the published studies were focussed on the leg, but studying the effects of arm tasks would be helpful to further improve arm rehabilitation. More research into the effects of educational or behavioural components would be beneficial to build on the positive results reported by Harrington et al (2010) and Marsden et al (2010) particularly in regard to reducing lifestyle stroke risk factors and increasing activity levels, both in the

hospital setting and in the community. And while stroke recovery guidelines and research studies suggest that therapy should be given with a high intensity, the exact optimal dose-response relationship remains unclear and needs further study.

Study	Design	Parameter	Outcome measure	Weighted mean difference
Wevers et al., 2009	Systematic review	Walking capacity	6 minute walk test	42.5 m*
		Walking speed	Gait speed (comfortable)	0.07 m/s*
		Mobility	Timed Up and Go test¥	-3.3 seconds*
		Postural control in standing	Step Test	2.8 seconds
			Berg Balance Scale	0.63 points
English & Hillier 2010	Systematic review	Walking capacity	6 minute walk test	76.6 m*
		Walking speed	Gait speed (comfortable)	0.12 m/s*
		Mobility	Timed Up and Go test¥	-3.08 seconds
		Postural control in standing	Step Test	3.00 seconds*
			Berg Balance Scale	0.86 points
			Activities Balance Confidence Scale	7.76 points*
		Length of stay	Number of days in rehabilitation hospital	-19.73 days*
				Mean difference
Outermans et al., 2010	Randomised controlled trial	Walking capacity	6 minute walk test	32.6 m*
		Walking speed	Gait speed (fastest)	0.3 m/s*
		Postural control in standing	Berg Balance Scale	0.1 points
			Functional Reach test	-0.4 cm

*denotes difference was statistically significant
¥This result does not include data from Mead et al (2007) as the paper did not report baseline values

Table 5. Summary of evidence for the effectiveness of circuit class therapy.

Very few studies to date have measured outcomes related to quality of life or psycho-social outcomes. Future research should include these outcomes to further enhance the understanding of the effect of group circuit class therapy on the holistic wellbeing of stroke

survivors. Fatigue and depression are often problems for stroke patients (Hackett et al., 2005; Choi-Kwon & Kim 2011). Several studies have shown that physical training produced a positive effect on non-physical outcomes like fatigue and depression (Sjosten & Kivela 2006; Blake et al., 2009; Mead et al., 2009). Therefore, there is the potential that group circuit class training could be a useful modality to address post-stroke depression and fatigue, and research into this area would be very useful for both clinicians and stroke survivors.

Patient and therapist satisfaction with group circuit class therapy is another under-researched area. English et al., (2007) found there were no significant differences in satisfaction with therapy from people receiving group circuit class therapy only compared to people receiving individual therapy sessions, although people in the circuit class arm were significantly more satisfied with the amount of therapy they received. A small study by Lynch et al (2008) investigating patient satisfaction with group circuit class therapy and individual therapy in a population of stroke survivors who received both models of care found that patients were satisfied with both methods of service delivery. Future research should investigate staff perceptions of implementing group circuit class therapy, and include qualitative outcomes regarding patient and therapist satisfaction.

2.5 Implementing group circuit class therapy in the clinical setting

Clinical guidelines for rehabilitation following stroke from countries around the world (van Peppen et al., 2007; Intercollegiate Stroke Working Party 2008; Lindsay et al., 2010; National Stroke Foundation 2010) recommend that stroke survivors should be provided with intense task-specific practice to aid in the recovery of arm function, and restoration of balance and mobility. The Australian guidelines specify that task-specific circuit class therapy should be used to increase the amount of practice in rehabilitation. Therefore, centres providing therapy to stroke survivors should consider providing task-specific group circuit class therapy to this population.

Implementing group circuit class therapy can be difficult as it often involves a change of practice for therapists used to providing therapy individually to their clients. Changing practice in the workplace is a specialty in itself, and the matter of implementing change is worthy of a chapter in its own right, however, an attempt will be made here to summarise the crucial points required to ease the transition when introducing an alternate method of therapy service delivery such as group circuit class therapy.

The barriers to implementing group circuit class therapy are similar to those of every other model involving a workplace change – generally when people are comfortable and confident in their practice, they will only want to change things for a compelling reason. Many people resist change as the process of change itself is challenging and at times confronting. Therefore, the implementation of group circuit class therapy requires a leader who can ‘sell’ the product of group circuit class therapy to the staff and clients involved. The evidence surrounding the effectiveness of this form of therapy, the anecdotally reported satisfaction levels of staff and participants, along with the relative cost-efficiency when compared to individual therapy should assist in this process. In an inpatient setting, negotiating the time of the group circuit class therapy with the wider multi-disciplinary team is important to minimise impact on other disciplines’ treatment planning. At sites where orderlies transport patients to therapy, planning is required if large numbers of patients will be attending therapy at one time. In an outpatient setting, organising a time

that fits with participant preference and transport services would be beneficial. It is these authors' experience that when the whole team is supportive of implementing group circuit class therapy, any obstacles that arise can be dealt with in a timely and efficient manner, and the introduction of group sessions runs smoothly.

Once the decision has been made to implement group circuit class therapy, a suitable therapy space must be located. The space must be able to accommodate the extra participants and staff along with the equipment required for circuit class therapy. No specialised equipment is necessary beyond that equipment found in the standard therapy area, and the equipment needs will vary to an extent on the population of the circuit class participants. For instance, in an acute stroke ward, more exercises are likely to be chair or plinth based as participants work towards goals of independent sitting balance or more independence in transfers, whereas in an outpatient setting, more exercises are likely to be standing or walking based. In both these examples, some seated exercises would also be required if arm function is being addressed within the circuit class. In general, chairs of different heights with and without armrests, steps of different heights, a designated walking space, access to stairs, tables at which to exercise the arm, real-world items (such as money, pens and paper, eating and cooking utensils, tools specific to participants' work or hobbies) with which to exercise the arm should all be considered when organising group circuit class therapy equipment. A treadmill is an additional useful, but not essential item. Table 6 provides a summary of all the exercises and activities reported in published trials of circuit class therapy. All trials stated that tasks were individually adapted and progressed as required such that the level of complexity, difficulty and dosage (number of repetitions) matched the individual's ability. In addition, the textbook by Carr & Shepherd (2003) is a valuable resource for activities and equipment that can be used in circuit classes.

The duration and frequency of group circuit class therapy may vary, depending on the population of stroke survivors participating in the therapy (whether they be inpatients or outpatients), and may vary if, in an inpatient setting, group circuit class therapy is used as a sole form of therapy, or used in addition to individual sessions. Recommendations from the literature are at least one hour of therapy, three times a week for four or more weeks regardless of the population of stroke survivors participating (English & Hillier 2010). If group circuit class therapy is the sole form of physiotherapy for inpatients following stroke, up to three hours a day, five days per week has been used in one study (English et al., 2007) and was a sustainable and clinically feasible option.

The structure of the class will also vary, depending whether the group circuit class therapy is the only method of therapy or is used as an adjunct to individual sessions. When group circuit class therapy is the sole method of physiotherapy service delivery, programs must be well tailored to each individual participant, and exercises must be constantly progressed to ensure that rehabilitation goals are met. This means that a flexible structure is required to allow the therapist to spend adequate one-on-one time with individual participants. For example a person requiring physical assistance to stand might receive 5 minutes of standing practice with a therapist while other class participants practice independently. The patient may then rest or do leg exercises in sitting or reaching out of the base of support independently while the therapist spends time with another participant practicing challenging balance activities in standing. In contrast, when group circuit class therapy is provided as an adjunct to individual therapy sessions, the aim of the classes may be more

centred on increased practice time of tasks, rather than meeting specific rehabilitation goals. Exercises should still be tailored to individuals and progressed regularly, but one-on-one time with therapists within the class setting may occur less often. In the group-circuit-class-only model of care, the occasional appointment with a therapist outside of circuit classes may also be required to address specific aims such as teaching family members how to assist their relative to get in and out of a car.

The number of staff providing group circuit class therapy needs to be determined, and this may vary depending on the nature of the participant group. For instance, in a community setting, where participants are for the most part mobilising independently, a lower staff to participant ratio will be required than in an acute stroke unit, where some participants may need assistance to sit, stand, transfer and mobilise. Suggested staff to participant ratios from the recent literature are 1:2 in very acute settings ([Zanker et al., 2007), and 1:3 or 1:4 for patients in inpatient rehabilitation (Blennerhassett & Dite 2004; English et al., 2007) and outpatient settings (Dean et al., 2000; Marigold et al., 2006; Mudge et al., 2009). Use of family or carers to provide assistance within sessions can also be considered on an individual basis, as this may ease the burden on staff, while providing valuable training to carers and family members regarding their family members' level of function, along with methods to assist their functional tasks and mobility. At least one member of the staff supervising the group circuit class therapy needs to have formal qualifications, as the supervising staff members need to have specific knowledge and skills to be able to tailor and progress the exercises appropriately for the individual participants.

Exercises within the group circuit classes must be tailored to the participants' current levels of function and their individual goals, and should be as specific as possible to the goal tasks. Therefore, it is necessary to have an assessment session or interview with each participant prior to commencing in the group circuit class. Depending on the referral source, this assessment/interview process may be conducted by the therapists delivering group circuit class therapy, or may in fact be done by the referrer, if they are a therapist knowledgeable about stroke rehabilitation. Generally, it is recommended that each participant have a program outline commenced prior to their first group circuit class session, which can be fine-tuned or progressed by the therapists supervising the sessions. It can be useful to have exercises divided into activities participants can do independently, and exercises requiring assistance so staff can manage their time efficiently, providing assistance to each participant when required, and setting them up with safe and effective exercises at other times. Exercises can be graded into levels which can help the therapist with exercise progression ideas; for example reaching to a bench in front, reaching to a stool down low, reaching to the floor. Judicious use of equipment and participant set-up can allow participants to exercise under supervision without hands-on assistance from a therapist where traditionally, a one-to-one treatment would have been used, such as positioning a participant usually requiring standby assistance next to a raised plinth or rail while performing sit-to-stand exercises. Depending on the individuals within the class, participants may be responsible for choosing and completing their exercises from their personalised programs within each session; other staff and participants may prefer to have the therapists directing how many repetitions or time spent on each specific activity. It is important that therapists progress exercises regularly in line with participants' functional abilities and goals in order for group circuit class therapy to maximise its effectiveness.

Organising participants to work together in pairs or small groups can also be an effective way of exercising as well as providing social interaction; for instance setting up participants so they throw and catch a ball to one another, alternately turn playing cards, count for each other as they perform sit-to-stand exercises, do relay races in teams for walking speed. This allows participants to watch other stroke survivors performing tasks which can enhance motor learning, as discussed in the section on neuroplasticity. It also allows the therapist time to provide one-on-one assistance to the participants as one participant performs the exercises while the other participant watches or rests (van de Port et al., 2009).

A final consideration is infection control. More of the community is being colonised with multi-resistant organisms such as multi-resistant staphylococcus aureus (MRSA) and vancomycin-resistant enterococci (VRE), and different health care sites have different regulations regarding how this population is managed. It is necessary to seek advice from local infection control authorities on how to manage people with multi-resistant organisms in a group setting if additional precautions are required. Conscientious hand-washing of staff and participants, use of personal protective equipment such as gowns and gloves by staff, wiping down of equipment and designated exercise areas should allow everyone to participate in a group session, regardless of their multi-resistant organism status.

Category of activity	Specific aim of exercise	Details of exercise	Progressions†	Reference/s
Warm up		Marching on spot		Salbach et al., 2004; Marsden et al., 2010)
		Walking overground or treadmill		Blennerhassett & Dite 2004; Marigold et al., 2006
		Stationary bikes		Blennerhassett & Dite 2004
		Stretches		Salbach et al., 2004; Marigold et al., 2006
Sitting balance	Promote loading of the affected leg and activation of the affected leg muscles	Sitting and reaching in different directions for objects beyond arm’s length		Dean et al., 2000; English et al., 2007; Marsden et al., 2010

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy.

Category of activity	Specific aim of exercise	Details of exercise	Progressions†	Reference/s
Sit to stand	Strengthen affected leg extensor muscles and practice task of sit to stand	Repeated standing up from a chair and sitting back down	Start with high chair or perching on the edge of a plinth Reduce seat height No arm-rests Non-affected leg on step Add dual task (eg holding cup of water) Increase speed	Dean et al., 2000; Blennerhassett & Dite 2004; Salbach et al., 2004; Pang et al., 2005; Marigold et al., 2006; Yang et al., 2006; English et al., 2007; Mead et al., 2007; Mudge et al., 2009; van de Port et al., 2009; Marsden et al., 2010; Rose et al., 2010
Standing	Improve postural control in standing	Standing with constrained base of support, with feet in parallel and tandem conditions	Narrow base of support Stand on foam Eyes closed Turning upper body Cross arms Stand on one leg	Dean et al., 2000; Pang et al., 2005; Marigold et al., 2006; English et al., 2007; Mudge et al., 2007
		Reach for objects, including down to the floor. Trace spiral on a whiteboard	Practice in pairs by passing objects Constrain and narrow base of support (eg stand with feet together, or in tandem)	Dean et al., 2000; Yang et al., 2006; English et al., 2007; van de Port et al., 2009; Marsden et al., 2010

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy. (Continuation)

Category of activity	Specific aim of exercise	Details of exercise	Progressions†	Reference/s
		Self sway in standing near a wall	Progress by increasing amplitude, then doing away from the wall	(Mudge et al., 2009
		Perturbations from a therapist		Marigold et al., 2006
		Stepping grid (participants stand with feet in marked areas, then tap one foot out to touch marks on floor, repeating with the other foot)		English et al., 2007
		Alternate toe tapping up onto a step in front	Tap foam cup on step without deforming it Higher step Decrease arm support	Salbach et al., 2004; English et al., 2007
		Kicking ball	Against wall, then dribbling ball around objects	Salbach et al., 2004; Pang et al., 2005; van de Port et al., 2009
		Throwing and catching balls in pairs or groups		English et al., 2007
Walking activities	Promote smooth transition between sit to stand and walking	Standing up from chair, walk short distance, return to chair	Chairs with no arms and reduced seat height	Dean et al., 2000; Salbach et al., 2004
	Endurance/fitness	Walking on a treadmill	Increase incline, speed	Dean et al., 2000
		Shuttle walks/brisk walking		Pang et al., 2005; Mead et al., 2007

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy. (Continuation)

Category of activity	Specific aim of exercise	Details of exercise	Progressions†	Reference/s
	Improve walking speed	Walk at fastest speed	Running	Salbach et al., 2004; van de Port et al., 2009
	Improve adaptability of walking skills	Obstacle courses (include over low obstacles, steps, ramps, foam surfaces)	Dual tasking (eg carrying tray of objects) Picking up objects from floor	English et al., 2007; Dean et al., 2000; Blennerhassett & Dite 2004; Salbach et al., 2004; Pang et al., 2005; Marigold et al., 2006; Mudge et al., 2009; van de Port et al., 2009; Rose et al., 2010
		Walking up and down stairs	No handrail	English et al., 2007; Dean et al., 2000; Blennerhassett & Dite 2004; Salbach et al., 2004; Marigold et al., 2006; van de Port et al., 2009; Marsden et al., 2010
		Sudden stops and turns during walking		Salbach et al., 2004; Pang et al., 2005
		Walking different step lengths, walking between parallel lines, , braiding (crossing one foot over in front), figure eight walking	Cross arms walking on a line, heel toe walking carry objects such as shopping bags	Salbach et al., 2004; Pang et al., 2005; Marigold et al., 2006; English et al., 2007; Mudge et al., 2009; Marsden et al., 2010

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy. (Continuation)

Category of activity	Specific aim of exercise	Details of exercise	Progressions†	Reference/s
		Walking backwards, sideways		Salbach et al., 2004; English et al., 2007
		Walking relay races		Dean et al., 2000; English., 2007; Outermans et al., 2010
		Walking outdoors		English et al., 2007
Leg strengthening in weight-bearing positions	Strengthen ankle plantarflexor muscles	Heel lifts in standing	Perform on a wedge/ramp Perform in single leg stance Jumps	Dean et al., 2000; Pang et al., 2005; Yang et al., 2006; English et al., 2007; Mudge et al., 2009
	Strengthen lower leg extensors	Stepping forward, backward and sideways onto blocks of various heights (participant places affected foot on a step either to the side or in front and raises him/herself onto the step)	Increase step heights	Dean et al., 2000; Blennerhassett & Dite 2004; Yang et al., 2006; English et al., 2007; Mudge et al., 2009; van de Port et al., 2009
		Squats	Increase angle of knee flexion	English et al., 2007
	Eccentric quads control	Participant stands on a step and lowers unaffected leg to the ground	Touch foot to a foam cup placed on the ground without crushing it before returning to the start position	English et al., 2007

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy. (Continuation)

Category of activity	Specific aim of exercise	Details of exercise	Progressions†	Reference/s
Other leg strengthening exercises		Reciprocal leg flexion and extension using Kinetron in standing		Dean et al., 2000
		Stationary bike riding		English et al., 2007
		Active hamstrings in sitting (sitting on chair, flex knee backwards)	Use towel or ‘slippery sam’ material to reduce friction to make easier, or strap on weights to make it harder	English et al., 2007
		Standing hams curl		Mudge et al., 2009
		Lunges		Mudge et al., 2009
		Side leg lifts		Mudge et al., 2009
		Marching in place	Marching on a mini-tramp	Marigold et al., 2006; Mudge et al., 2009
Endurance/fitness		Cycling ergometry		Mead et al., 2007
		Raising and lowering 1.4kg medicine ball		Mead et al., 2007
Arm strengthening		Resistance band exercises for shoulder flexion, abduction, extension, external rotation		Pang et al., 2006; English et al., 2007; Mead et al., 2007

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy. (Continuation)

Category of activity	Specific aim of exercise	Details of exercise	Progressions†	Reference/s
		Cuff weights for elbow flexion and extension, wrist extension and flexion		Pang et al., 2006; English et al., 2007
		Hand muscle strength (putty and grippers, pinch, grip, finger extension)		
		Electrical stimulation for those with no wrist extension	100 Hz, 150 microseconds, ON, 10 sec OFF time 10 sec, ramp 1 sec, treatment time 10-15 minutes	Pang et al., 2006
		Upper extremity weight-bearing on a physiotherapy ball or push up on arms of a chair		Pang et al., 2006
		Active shoulder girdle movement with arm supported on high table, including protraction, external rotation		English et al., 2007
Arm range of movement		Passive or self assisted range of movement exercises to paralyzed joints		Pang et al., 2006

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy. (Continuation)

Category of activity	Specific aim of exercise	Details of exercise	Progression†	Reference/s
		Prolonged shoulder positioning in either forward flexion or abduction	Use of circumferential elbow foam splint where elbow contracture or stiffness is an issue	English et al., 2007
		Active pronation and supination		English et al., 2007
Functional arm tasks		Playing cards	Could be done in pairs	Pang et al., 2006; English et al., 2007
		Picking up objects various sizes and shapes		Pang et al., 2006; English et al., 2007
		Taking lids on and off jars		English et al., 2007
		Pegging washing on a line		English et al., 2007
		Folding washing		English et al., 2007
		Scooping coins of the edge of a table		English et al., 2007
		Spooning or pouring water from cup to cup		English et al., 2007
		Lifting and moving a pen around a marked grid		English et al., 2007

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

Table 6. Summary of exercises and activities reported in published trials of circuit class therapy. (Continuation)

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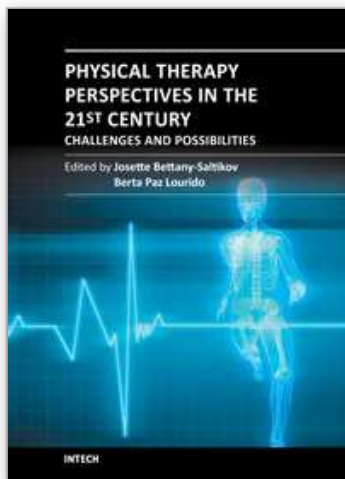
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Physical Therapy Perspectives in the 21st Century - Challenges and Possibilities

Edited by Dr. Josette Bettany-Saltikov

ISBN 978-953-51-0459-9

Hard cover, 386 pages

Publisher InTech

Published online 05, April, 2012

Published in print edition April, 2012

This book contains new information on physical therapy research and clinical approaches that are being undertaken into numerous medical conditions; biomechanical and musculoskeletal conditions as well as the effects of psychological factors, body awareness and relaxation techniques; specific and specialist exercises for the treatment of scoliosis and spinal deformities in infants and adolescents; new thermal agents are being introduced and different types of physical therapy interventions are being introduced for the elderly both in the home and clinical setting. Additionally research into physical therapy interventions for patients with respiratory, cardiovascular disorders and stroke is being undertaken and new concepts of wheelchair design are being implemented.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Coralie English, Ingrid van de Port and Elizabeth Lynch (2012). Group Circuit Class Therapy for Stroke Survivors – A Review of the Evidence and Clinical Implications, Physical Therapy Perspectives in the 21st Century - Challenges and Possibilities, Dr. Josette Bettany-Saltikov (Ed.), ISBN: 978-953-51-0459-9, InTech, Available from: <http://www.intechopen.com/books/physical-therapy-perspectives-in-the-21st-century-challenges-and-possibilities/group-circuit-class-therapy-for-stroke-survivors-a-review-of-the-evidence-and-clinical-implications>

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