Chapter 9
Clinical Evidence of Exercise Benefits for Stroke

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Abstract Even though stroke is the third, not the first, most common cause of disability-adjusted life years in developed countries, it is one of the most expensive to treat. Part of the expense is due to secondary problems in the post-stroke period including: cognition, memory, attention span, pain, sensation loss, psychological issues, and problems with mobility and balance. Research has identified that exercise has both positive physical and psychosocial effects for post-stroke patients. Therefore, this scientific statement provides an overview on exercise rehabilitation for post-stroke patients.

We will use systematic literature reviews, clinical and epidemiology reports, published morbidity and mortality studies, clinical and public health guidelines, patient files, and authoritative statements to support this overview.

Evidence clearly supports the use of various kinds of exercise training (e.g., aerobic, strength, flexibility, neuromuscular, and traditional Chinese exercise) for stroke survivors. Aerobic exercise, the main form of cardiac rehabilitation, may play an important role in improving aerobic fitness, cardiovascular fitness, cognitive abilities, walking speed and endurance, balance, quality of life, mobility, and other health outcomes among stroke patients. Strength exercise, included in national stroke guidelines and recommended for general health promotion for stroke

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survivors, can lead to improvements in functionality, psychosocial aspects, and quality of life for post-stroke patients. Flexibility exercises can relieve muscle spasticity problems, improve motor function, range of motion, and prevent contractures. Stretching exercises can also prevent joint contractures, muscle shortening, decrease spasticity, reduce joint stiffness and improve a post-stroke patient's overall function. Neuromuscular exercises can improve activities of daily living (ADL) through coordination and balance activities. Traditional Chinese exercises are used to improve walking and balance ability as well as increase muscle strength, which is important for post-stroke patients.

The present evidence strongly supports the power of exercise for post-stroke patients, which in this study combined aerobic exercises, strength training, flexibility exercises, neuromuscular exercises, and traditional Chinese exercises. This research can encourage post-stroke survivors to consider the importance of exercise in the rehabilitation process.

Keywords Clinical evidence • Exercise • Stroke

Transient ischemic attack (TIA), ischemic stroke, and intracerebral hemorrhage are all terms used to describe a stroke. Once a patient has had a stroke, there is an elevated risk for future vascular events and this risk is increases even more in those with cardiac-cerebral vascular disease.

Compared with other cardiovascular diseases, a stroke is the third largest cause of disability-adjusted life years in developed countries. Approximately 0.4% of Western country population have had stroke by the age of 45. Around half of those who have experienced a stroke have a lifelong disability. In addition, the incidence of stroke has increased because of the global population growth, the obesity epidemic, diabetes, heart failure, and the overall lack of physical activity among the general population. In the United States, the prevalence of stroke has increased by almost 25% since 2010. It is predicted that an additional 4 million people will suffer a stroke by 2030, which contributes to the country's overall healthcare costs.

Post-stroke improvements in the individual vary due to the nature and severity of the primary deficit. It is reported that up to 35 percent of stroke survivors with initial leg paralysis are unable to regain physical function and 20–25 percent are unable to walk without full physical assistance. Six months after a stroke, about 65 percent of patients are unable to incorporate the affected hand into their daily activities. In addition, there are several post-stroke long-term physiological, mental, and psychological problems, including movement and function, balance, pain, sensation, perception, cognition, attention, memory, and emotional problems. About half of post-stroke survivors report that their stroke-related problems are unmet. Therefore, effective stroke rehabilitation is an indispensable part of stroke care.

This overview will address if exercise benefits are meaningful to stroke patients. It will also review how the effects from exercise align with the needs of stroke survivors. In the 2014 Scottish Stroke Nurses Forum (SSNF), 10 post-stroke priorities were identified and the most important intervention that was repeatedly mentioned was exercise [1].

Exercise can positively influence several physical and psychosocial domains after a stroke. After a stroke, evidence shows that exercise can improve cardiovascular fitness, walking ability, and muscle strength. Exercise has primarily been used to improve physical function after stroke, but emerging research suggests that exercise may improve depressive symptoms, some executive functioning, memory, fatigue, and other health-related quality of life for post-stroke patients.

Post-stroke patients can benefit from exercise training; however, most healthcare professionals lack experience in exercise programming in this patient group. Therefore, this scientific statement will help to fill the current post-stroke exercise rehabilitation knowledge gap. Thus, the aim of this section is to detail the effects of various kinds of exercise rehabilitation in post-stroke patients.

1 Benefits of Aerobic Exercise in Post-Stroke Patients

In the past decade, post-stroke aerobic exercise has gained more attention and recognition from both clinicians and researchers. Aerobic exercise training plays a vital role in promoting aerobic fitness, cardiovascular fitness, cognitive, walking speed and endurance, balance, mobility, quality of life, and other health outcomes among post-stroke patients. The American Heart Association (AHA) also recommends regular aerobic exercise as part of stroke prevention and treatment [2]. Aerobic exercise, the main part of cardiac rehabilitation, is an integral part of stroke rehabilitation and cannot be considered a substitute for conventional drugs or surgery treatments. Recent research reports that the influence of aerobic exercise for post-stroke patients and the need to implement post-stroke exercise programs is crucial.

1.1 Cardiorespiratory Fitness

It is reported that a person with a low cardiorespiratory fitness level has an increased risk of a having a stroke. Even though higher levels of cardiorespiratory fitness to lower a person’s stroke risk have not been well established, aerobic exercise can improve cardiopulmonary fitness in post-stroke patients. Systematic reviews [3–5] in recent years have showed that aerobic exercise can enhance the elasticity of the heart and lung, which is effective in improving peak VO2, 6 meter walk test (6MWT), forced vital capacity (FVC), peak workload, and other cardiopulmonary functions in stroke patients. For example, Globas et al. [6] used treadmill walking starting at a 40–50% heart rate reserve (HRR) and then up to a 60–80% HRR, initially 10–20 min and up to 30–50 min, respectively, 3 times per week for a total of 13 weeks. They discovered that a peak VO2 (measure of the maximum volume of oxygen) increased by 29% and the 6 MWT increased by 21% after 3 months of exercise. Lennon et al. [7] studied the peak heart rate achieved during an exercise test as an outcome. Intervention courses attended 30-min cycle ergometry exercise using the upper or lower limbs twice per week for a 10-week duration. Lennon et al., set a maximal heart rate of 50–60% as a biofeedback alarm during exercise. The primary outcome measures were cardiac risk score (CRS); VO2 (mL O2/kg per minute) and a Borg Rate of Perceived Exertion (RPE) during a standardized ergometry test. The results revealed that group comparison with independent t-tests were significantly improved compared to the control group in VO2 and CRS at follow-up. Of note, the RPE rating decreased in intervention individuals and increased in the control group.

In clinical practice, aerobic exercise has been suggested to become a positive, task-oriented intervention to promote cardiovascular fitness. Cardiorespiratory fitness with aerobic exercise training protocols of at least 8–12 weeks (intensity 50–80% of HR(max); 3–5 days per week; 20–40 min) has helped to improve the lives in patients who have experienced a mild to moderate stroke.

1.2 Cognitive Function

Over a third of stroke patients exhibit permanent sequelae of cognitive impairment [8]. Cognitive deficits resulting from a stroke, even from a mild impairment, can have a negative effect on physical rehabilitation, social functioning, and independence and are also associated with long-term morbidity and disability. Therefore, it is necessary to find effective treatments for cognitive impairment in individuals who have suffered a stroke. Recent meta-analyses confirmed that aerobic exercise can enhance cognitive performance in a healthy population [9]. In addition, many systematic review studies in post-stroke patients involve aerobic training [10, 11]. For example, Cumming et al. [11] conducted a systematic review to evaluate the effects of physical activity on cognitive function in stroke survivors. They included all controlled clinical studies and randomized controlled trials that assessed the influence of physical activity or exercise on cognitive function in stroke. The literature search found evidence that increased physical activity can improve cognitive performance in stroke survivors. Exercise can improve oxygen consumption, increase cerebral blood flow, and promote brain cell regeneration in the encephalic regions related to cognitive function.

Cognition is not a unitary concept because it incorporates many other aspects, including executive function, attention, visuospatial ability, memory, and language [12]. Attention, visuospatial ability, and language were reported in a El-Tamawy et al. [13] study of thirty stroke patients. They were divided into two groups: (G1) received a conventional physiotherapy program and (G2) performed aerobic exercise in addition to a routine program. Then, they compared the cognition function between the 2 groups using the Adenbrookes's Cognitive Examination-Revised (ACER) assessment. The study showed a significant improvement in ACER attention scores. A pilot study also described changes in measures of executive function in long-term stroke patients following aerobic and strengthening exercise [14]. In this study, nine stroke patients completed a 12-week aerobic and strengthening exercise program that occurred 3 days per week. Executive function was examined by Digit Span Backwards and Flanker tests. The results showed significant improvements following the intervention in the Digit Span Backwards test and a significant correlation on the Flanker test. To decide if a combined exercise could improve the memory of long-term stroke patients, 11 ambulatory participants with chronic stroke took part in a program of exercise for 2 h and recreation for 1 h weekly for 6-months [15]. They, then evaluated the memory of the study participants (Rey Auditory Verbal Learning Test—long delay) at baseline and at 3 months and found that the mean improvement was 61% ± 69, which indicates that exercise and recreation may improve the memory of stroke survivors. Further clarification is needed to determine which types of exercise interventions can benefit cognitive function following a stroke.

1.3 Functional Performance

More than 50% of stroke survivors report gait disability or an abnormal gait pattern [16]. The multiple physical impairments that can result from a stroke may lead to a physically inactive lifestyle and induce a vicious cycle of deficient physical function. Therefore, aerobic exercise training may break the vicious cycle of physical inactivity and functional decline, and have an important effect on improving the functional performance of stroke patients.

1.3.1 Balance

Aerobic exercise has beneficial effects on the balance function of stroke patients. In clinical trials, balance scales (e.g., Berg balance score, [BBS]) and balance tests (e.g., Timed Up and Go Test [TUGT] the Four-Square Step Test, and Functional Reach Test) are commonly used to assess balance. A recent review study [4] reported a significant balance improvement following 4 weeks of 20–30 min of cycling or body weight supported treadmill training. Gama et al. [17] conducted a study with 28 subjects with hemiparesis and divided them into two groups. The participants underwent partial bodyweight-support treadmill training for the twelve 20-min training courses 3 times per week. After the 12 training sessions, the participants were assessed the balance by the BBS. The study reported that 8 weeks of moderate aerobic exercise significantly improved functional balance. To understand aerobic exercise-induced improvements in balance function after stroke, Quaney et al. [18] had 38 chronic stroke survivors randomized to 2 different groups who exercised 3 times a week (45-min sessions) for 8 weeks. The aerobic exercise group (n = 19; 9 women; 10 men; 64.10 ± 12.3 years) did a stationary bicycle training program, while the other group did a stretching exercise program (n = 19; 12 women; 7 men; 58.96 ± 14.68 years) by doing stretches at home. Participants in the aerobic exercise group performed stationary bicycle under the supervision of a physical therapist and exercise physiologist with an aerobic exercise target level equal to 70% maximal (max) heart rate (HR) for 45 min (based on Karvonen's formula), 3 times per week for 8 weeks. At the end of the 8-week study, changes in performance at "post" and "retention" (8 weeks later) for neuropsychological and motor function between the two groups were measured. The BBS measured balance and coordination while standing and sitting, a trend toward significance in BBS Control was observed at 8 weeks after baseline and then reached significance at 16 weeks after baseline. A 3-month aerobic training program showed a significant improvement in the balance ability of stroke patients. In the Batcho et al. study [10], a total of 44 stroke patients were recruited in a European high-income area (Belgium) and in an African low-income country (Benin). The 3-month exercise intervention included a 3 times/week group-based brisk walking program. Study participants had to walk at their fastest pace on a regular surface. It was reported that the study participant's balance function improved significantly after this intervention.

Aerobic exercise has beneficial effects on stroke patients' balance function, regardless of the training type, intensity (mild, moderate or high), and duration (3–5 days per week; 4 weeks to 3 months).

1.3.2 Walking Speed

Disability from a stroke can lead to a sedentary lifestyle and may induce long-term physical deconditioning and interfere with walking ability. It also can lead to further decline of cardiovascular fitness. Poor cardiovascular fitness has been associated with a higher stroke risk and stroke mortality. Most studies have found that aerobic exercise training can improve walking speed [3]. Thirty-eight subjects who had suffered a stroke over 6 months and who had residual hemiparetic gait were enrolled in the Globas et al. [6] study. To compare the effects of 3 months (39 sessions) and test the efficacy of aerobic treadmill exercise (TAEX) with usual care physiotherapy (control) according to the typical German prescription (1–3 sessions/week), they adopted a randomized controlled design. The primary outcome measure was a sustained walking capacity in the 6 MW. The secondary measures were gait velocity during a 10-min walk. Thirty-six participants completed the study (18 TAEX, 18 controls), which showed that TAEX, and not conventional care, improved the 6 MW (53 m, $P < 0.001$). In addition, the maximum walking speed (0.13 m/s, $P = 0.010$) also improved after TAEX. Better walking was related to a progression in treadmill velocity and training duration. Compared to the baseline, 6 MW performance remained high even 1 year after the end of training. This trial shows that TAEX can improve gait and cardiovascular fitness effectively in post-stroke individuals.

The improvement in walking speed may be due to repeated gait practice at a higher speed. An improvement in maximum walking speed was significantly related to a progression of treadmill velocity and training duration. Previous aerobic exercise intensity studies reported that even at the low end-range of the targeted heart range (HR) and increased in intensity, progressions were reported in brachial artery vasomotor reactivity as well as walking speed [19], was set to maintain HR between 50 and 59% of HR reserve for weeks 1–4 and increased to 60–69% during weeks 5–8. The exercise duration began at 20 min with a final goal of 30 min of persistent exercise at a specified workload. A peak exercise test evaluated exercise capacity and found that the mean exercise test time increased from the initial assessment at baseline. At the 1-month follow-up, only peak watts and RPE maintained a significant difference from baseline. However, further walking speed improvements after exercise may be more distinct if the participants perform a more scheduled walking task [3].

1.3.3 Endurance

Endurance is a difficult issue for post-stroke individuals. The meta-analysis [3, 4] also showed that aerobic exercise is effective in inducing walking endurance. One 4-week study [20] compared intensive aerobic exercise for 30 min a day to traditional physical therapy that occurred once per day for 5 days per week. The controlled group performed an aerobic exercise for 30 min and the other group had a physical therapy session for 30 min a day, 5 days a week. After the intervention, the two groups measured the forced vital capacity, forced expiratory volume in 1 s, 10-m walking test, and 6-min walking test. After the intervention, the comparison between the two groups showed that the experimental group achieved more significant improvements in the forced vital capacity, forced expiratory volume in 1 s, and 6-min walking test. The results indicate that intensive aerobic exercise had a positive role in respiratory capacity and walking endurance in post-stroke patients. Another study [21] of 28 patients who had experience a post-minor ischemic stroke in the previous 1–3 weeks were randomly divided into intervention or control groups. The 6-week intervention training consisted of a session of 35–55 min on a treadmill, a hand bike machine and a bicycle, twice a week for 3 h a week, and the pulse rate target was set at 50–70% of the maximal heart rate. The per protocol analysis found a significant interaction effect, but only in the intervention group participants as they showed a significant clinical change in the 6 MWD test (412 ± 178 m to 472 ± 196 meters vs. the control group 459 ± 116 m to 484 ± 122 m $p < 0.01$).

Aerobic exercise can improve endurance in post-stroke patients, regardless of the training type, intensity (mild, moderate or high), and duration of the intervention. Aerobic exercise can improve can improve physical function and allow patients to return to their family and community (Table 9.1).

Table 9.1 Optimal parameters to affect stroke outcomes

Outcomes	Frequency	Duration	Intensity
Cardiorespiratory fitness	3–5 days/week; 20–40 min/ per day	8–12 weeks	Moderate-high
Cognitive function	>3 days/week; about 30 min	Over 4 weeks	Unknown
Functional performance			
Balance	3–5 days/week; 20–30 min	4 weeks to 3 months	Mild-high
Walking speed	3–5 days/week; 20–30 min	8–12 weeks	Mild-moderate
Endurance	3–5 days/week; 20–30 min	4–6 weeks	Mild-high

2 Benefits of Strength Exercise

Strength exercise, also known as resistance exercise (RE), as a form of rehabilitation, has been included in national stroke guidelines and is recommended in post-stroke patients to improve their overall health.

Muscle weakness is a common physical impairment and a leading target of secondary injury following a stroke [22]. Even though, strength exercises remain an understudied and underappreciated exercise modality for stroke patients when compared to aerobic exercises, Strength training can improve functionality, psychosocial aspects, and the quality of life in stroke individuals. Resistance exercise is used in rehabilitation programs to improve muscle strength [23], thereby improving functional ability and the overall quality of life.

2.1 Improve Muscle Strength and Endurance

Muscle tissue loss caused by secondary stroke injury and from a sedentary post-stroke life-style can lead to metabolic and endocrine related disorders. Two studies reported positive effects on muscle strength after 10–12 weeks of progressive resistance training compared to a control group, with a 30–70% increase in knee extension or flexion and a 15–35% increase in plantar flexion of the ankle. Lee and Kang [24] found that isokinetic eccentric resistance exercise (8 repetitions per set for 4 sets, 60 min per day, 3 days per week for 6 weeks, at an angular velocity of 90°/sec) can improve hip muscle strength. Vinystrup et al. [25] found that by increasing velocity (full available range of motion (ROM) for 3 repetitions at a 10 repetition max (RM) load) during heavy resistance knee flexion exercise improved muscle activity levels. Furthermore, Frederick et al. [26] found the participants who accepted strength exercise (2 sets of 20 repetitions on each leg, 45 min per day, 3 days per week for 3 months) had a significantly greater skeletal muscle endurance ability compared to a control group in both the paretic (178% vs. 12%) and non-paretic legs (161% vs. 12%). Kim et al. [27] also reported positive effects on muscle strength after 10 weeks of strength training for the lower extremity, but did not find a significant difference between the intervention and control group.

2.2 Improve Walking Performance and Balance

Since, muscle strength is closely associated with walking performance [28], one purpose of stroke rehabilitation is to improve muscle strength and thereby enhance walking ability [29]. Most of the RE studies reported a positive improvement in walking performance. Another meta-analysis suggested that performing a lower limb resistance training program in community-dwelling patients who had a stroke after 6 months improved their gait speed and total distance walked [30]. Similarly, a 2008 review proposed that resistance training increases strength, gait speed, and functional outcomes, and improves quality of life in post-stroke patients [31]. Bale and Strand [32] reported that strength exercise performed based on the principle of 10–15 repetitions maximum resulted in significant gait speed improvements after strength training when compared to the control group.

Several studies have addressed the effects of strengthening exercise on gait performance (activity) and perceived participation (presented in Table 9.2). Park et al. [22] evaluated the effects of a progressive RE training program on walking ability in post-stroke patients and found that it can increase walking speed and decrease a 10-m walking time. Clark et al. [37] studied a dynamic high-intensity resistance training program over 5 weeks followed by 3 weeks of a clinic-based gait training and found that bilateral neuromuscular activation, strength, and walking speed improved in post-stroke patients. Lower limb training for 10–12 weeks can increase gait speed, and quality of life according to the Duncan et al. [34] and Flansbjer et al. [36] studies.

Fitness and mobility exercises can also increase gait distance in post-stroke patients [35]. Rodrigo et al. [38] performed closed-chain knee extensions in post-stroke patients and found a significant improvement in balance function and gait performance for these study participants. However, resistance training should involve monitoring the patient's heart rate, blood pressure, and subjective feelings.

2.3 Improve Functional Outcomes

A systematic review [40] reported that post-stroke strength exercise can result in an improvement of functional activity and quality of life measured by self-assessment scales such as the Short-Form 36 (SF-36), Maximal Activity Score (MAS), Nottingham Health Profile (NHP), Human Activity Profile (HAP), or the Barthel Index. Michelle et al. [41] found that a high-intensity progressive resistance training (3 sets of 8–10 repetitions, 3 times per week for 12 weeks at 70% 1RM) induced an improvement in self-reported function and disability. In addition, a single-blinded RCT [42] of 36-sessions over 12-weeks in a home-based exercise program that targeted strength (active motion in PNF unilateral patterns with manual resistance progressing to Thera band repetitions in 2 sets of 10) showed an improvement in physical and social aspects.

Table 9.2 Effects of strengthening exercise on gait performance and perceived participation

Study	Design	Intervention	Effects on gait performance
Bourbonnais 2002 [33]	RCT	Lower limb hip and knee (40–90%)	Sign between group differ for gait speed but not for TUGT
Duncan 2003 [34]	RCT	Manual resistance and terraband 10 reps, 2 sets, 90 min sessions, 12 w	Gait speed increased 26%, more significantly in intervention group
Pang 2005 [35]	RCT	Fitness and mobility exercise; intensity and duration increased as tolerated during the trial, 1 h, 3 days/week, 19 weeks	Significant difference for gait distance
Flansbjer 2008 [36]	RCT	PRT knee ext/flex both lower limbs, 2 sets, 6–8 reps 2 days/w, 10 w	Gait performance improved in both group. After intervention, there is significantly different in intervention group in follow up.
David 2013 [37]	RCT	Using an isokinetic dynamometer. 3 sets of 10 repetitions at each of 3 criterion speeds. 3 times weekly. 5 weeks of dynamic high-intensity resistance training followed by 3 weeks of clinic-based gait training	Improve bilateral neuromuscular activation, strength, and walking speed
SungMin 2014 [23]	RCT	3 sets (8–10 repetitions per set) of resistance exercise at 70% of the 1-repetition maximum (1RM) to strengthen muscles across multiple joints. 5 days per week, for a period of 6 weeks	Improve antero-posterior (A-P) and medio-lateral (M-L) sway distances, and TUGT times decreasing
Byoung 2015 [22]	RCT	Resistance weight was progressively increased from 30 to 40 kg and then to 50 kg. 3 sets of 11 presses and extensions for each weight increment. 30 min per time. 3 days/weeks for the 6 weeks	Increase walking speed and affected side stride length. Decrease 10-m walking time
Jennifer, 2016 [38]	RCT	POWER training, 40% 1 RM; 24 sessions; 8–12 repetitions	increases gait speed
Rodrigo 2016 [39]	RCT	4 sets of 7 maximal closed-chain knee extensions; <2 min of contractile activity per session; 12 weeks, 2 times/week	Enhance balance (8.9%), gait performance (10.6%), dual-task performance

2.4 *Other Exercise Benefit Aspects*

Other strength exercise benefits include an improvement in respiratory function, cognitive function, and anxiety. Song and Park [43] found that respiratory function (FVC, FEV1) and trunk control ability significantly improved after the exercise intervention (an chest resistance exercise program in moderate intensity supervised by therapist, 30 min/time, 5 times/week for 8 weeks) in stroke patients. Marzolini et al. [44] found that resistance training (once per week for 6 months, 50% or greater 1 RM, and/or a resistance rated as 13–14 on the Rating of Perceived Exertion Scale, gradually progressed from 10 to 15 repetitions and then increased the resistance by 1.6–5 kg or increased the exercise band level) helped to improve mild cognitive impairment following stroke. A pilot study [45] indicated that resistance exercise (3 sets of 8–10 repetitions with the same intensity, in accordance with the values of the OMNI Scale, 45–60 min at a time, 3 times per week for 12 weeks) improved anxiety in those who had experienced an ischemic stroke.

3 Benefits of Flexibility Exercise

About 65% of all stroke patients have suffered spasticity, which may result in functional limitation because of muscle tightness and joint stiffness. Spasticity can also impair motor function. Evidence now suggests that flexibility exercises may benefit stroke survivors. The goal of a flexibility program is to relieve spasticity, improve motor function, range of motion, and prevent contractures. Stretch training involve basic management techniques, which include flexibility exercises and joint movements by their ranges of motion (ROM) through an external force [46, 47]. It is suggested that stretch training can prevent joint contracture and muscle spasticity [48], relieve spasticity [47, 49], decrease joint stiffness [46, 50] and improve functional activity [46].

3.1 Increase ROM

Joint range of motion is also improved transiently after flexibility exercises, chronically after about 3 or 4 weeks of regular stretching at a frequency of at least 2–3 times per week [51–56]. These flexibility exercises may improve the patient in as few as 10 sessions with an intensive program [57]. When flexibility exercise is used for warm-up training or combined with resistance training and aerobic training, it can help stroke patients increase their ROM. In Hyun-Ju Jeon et al. study, patients with post-stroke hemiparesis were assigned randomly to the experimental or control group. Changes in ROM was then measured in the experimental and control groups of the Monkey Chair and Band program at weeks 0, 4, 8, and 12. Significant differences were found in shoulder flexion at baseline and weeks. The experimental group showed a remarkable increase in ROM over time. In the control group, however, there were no remarkable improvements in ROM [58]. In another trial, stroke patients prescribed a ROM and flexibility routine carried out in class and home combined with resistance training or aerobic training of 90 min per day for 6 months reported a remarkable increase in joint ROM [59].

3.2 Prevent Contractures

Spasticity problems after a stroke can lead to muscle weakness and soft tissue contracture, pain, and spasticity appear within 1 week and contracture can occur within 2 weeks after a stroke [60, 61]. Data suggests that stretch training can effectively improve spasticity and motor function in post-stroke subjects with severe spasticity and weakness. Fan Gao et al. used an ankle stretching device with stroke patients, which included 12 sessions in sequence that each lasted 5 min with a 30 s break in between. Around 120 stretching cycles occurred, which lasted about 1 h. Stroke survivors had a significantly higher resistance torque and joint stiffness than the healthy controls before an intervention. After repeated stretching, Fan Gao et al. found that stroke survivors had a significant reduction in ankle joint stiffness and resistance torques [62]. In a randomized, controlled study of 21 stroke patients, a wrist-hand stretching device was used for stretching exercises, which were performed with three different weight bearing positions for 14 min. The 4-weeks stretching program was conducted in 3 sessions per day for 6 days per week in the patient's own home or office. A significant improvement in spasticity severity and motor function was observed [63]. In another study, a static stretching device was used on stroke patients, the exercise lasted 10 min per session and was performed every day for 2 sessions per day for 4 weeks. Findings showed that the static stretching device effectively improved spasticity and motor function in post-stroke patients with severe spasticity and weakness [64].

3.3 Increase ADLs

Stroke disability may lifelong and can limit an individual's independence and activities of daily living (ADL) [65]. The studies conducted on home-based exercise suggest that it can effectively improve mobility in post-stroke patients [66]. In a randomized controlled pilot study, 72 individuals with subacute ischemic stroke were instructed to start an exercise program. The exercise program combined flexibility and resistance exercises. Each exercise session lasted 1 h and occurred twice per week for 12 weeks. In this home-based exercise program, gains were observed in ADL and mobility [67].

In conclusion, flexibility exercise programs that combine resistance training or aerobic training can remarkably improve range of motion (ROM) in stroke patients. Flexibility exercises are an effective method to improve spasticity, motor function, increase ADLs, and prevent contractures.

4 Benefits of Neuromuscular Exercise

Recent studies have indicated that gait impairments usually persist after stroke, such as walking slowly and spatial-temporal asymmetry The ability to adapt a gait pattern is required to walk safely in the community [68]. Such phenomenon creates numerous needs on the neural processes included in the control of medial-lateral (ML) stability. Due to the importance of turning in daily mobility [69], and the increased risk of falls and damages when turning [70], it is essential that post-stroke patients learn neuromuscular exercises to improve his or her ADL safety level through coordination and balance activities.

4.1 Promote Mobility

Beyond the promotion on the balance capability, perturbation training benefits the stroke patients' independent mobility. In a randomized controlled trial [71], participants who suffered a stroke were assigned to one of two groups: the perturbation training group and the traditional balance training group. Both manual perturbations (e.g., a push or pull from a physiotherapist) and rapid voluntary movements to cause a loss of balance. Perturbation training occurred twice per week for 6 weeks. With 1 year falls monitoring period and the Physical Activity Scale for Individuals with Physical Disabilities (PASIPD) and the Subjective Index of Physical and Social Outcome (SIPSO) to conform the risk of falls and physical activity and participation, we found that the occurrence of falls and activity limitations among post-stroke participants had been reduced. In addition, the functional balance and mobility had improved in the perturbation training group.

4.2 Improve Trunk Control

Another neuromuscular treatment that harnesses weight-shifting training (WST) on a precarious surface can produce significant effects on trunk stability, proprioception, and balance in participants with chronic hemiparetic stroke. One of main problems following a stroke is trunk instability. Eighteen participants were recruited and allocated to either WST or a control group in an observer-blinded and a pilot randomized controlled study [72]. The WST group included a weight-shift training program for 30 min and then a traditional exercise program for 30 min, while the control group received traditional exercise program for 60 min, 5 times a week for 4 weeks for both groups. Three outcome measures were used: trunk reposition error (TRE) to the target angle during his/her active trunk movement, trunk impairment scale (TIS) to measure trunk control abilities, and TUGT to measure dynamic balance abilities. After training, the TRE, TIS and TUG test scores showed a significant improvement in the WST group compared to the control group. These findings suggest that weight-shift training contributes to an improvement in trunk control and proprioception in individuals who have experienced a chronic hemiparetic stroke.

4.3 Improve Balance

Virtual reality training (VRT) allows post-stroke patients to interact with a virtual environment using computer software and hardware and can promote balance ability. In a randomized test control group design [73] that involved 22 stroke patients, the patients were divided into a video-game system (VRBT) group to use virtual-reality balance training and the others were in a control group. Both groups were provided a rehabilitation training program (physical and occupational therapy) for 60 min a day, 5 times a week for 6 weeks. The VRBT group took part in VRBT for 30 min a day, 3 times a week for 6 weeks. Dynamic balance ability was evaluated with the BBS while balance and mobility in balance was measured by a TUGT. Compared with the control group, there was a greater improvement on BBS and TUGT in the VRBT group.

Balance ability disorders not only impair daily functional activity, but also limit both physical and social activity. The normalization and/or restoration of the impaired balance function after a stroke has. Promoted efforts for effective balance training [74]. It appears based on our review that video game therapy and balance training can help individuals who have suffered from a stroke to regain their balance and reduce their fall risk.

5 Benefits of Traditional Chinese Exercise

Traditional Chinese exercises, which can include Tai chi, Baduanjin, Yijinjing, and Liuzijue involves a theory of mental and physical exercise. It is a self-methodology which was created by ancient Chinese. Traditional Chinese exercises are suitable for elderly people because it is easy to learn, low cost, highly safe, and provides an appropriate level of aerobic exercise. Due to the combination of physical movements with mental focus and relaxation [75, 76], traditional Chinese exercise offers additional benefits to traditional stroke rehabilitation. Some research states that traditional Chinese exercises can improve the ability of walking and balance and enhance muscle strength to improve motor system function [77, 78].

Tai chi is a popular exercise method among the elderly and is a traditional Chinese exercise, especially in Asia. It is considered a complex, multicomponent intervention that involves physical, psychosocial, spiritual, emotional, and behavioral elements [79]. As an exercise for promoting health, Tai chi has been practiced for hundreds of years in China and is gradually becoming accepted in Western countries. A systematic review indicated that intensive Tai chi exercise had some favorable effects on improving general cardiorespiratory fitness and functional status. In addition, Tai chi was potentially beneficial for cardiovascular disease in the elderly population, including stroke patients [80].

5.1 Improve Balance and Gait

Kim H et al. [81] found that the Tai chi experimental group (60 min at a time, twice weekly which consisted of 10 different movements for 6 weeks) demonstrated a statistically significant difference in the functional reach test and the dynamic gait index (which were used to evaluate dynamic balance). The experimental group demonstrated a statistically significant difference in both sway length and sway velocity. The average changes in the 10-min walk test and timed up and go test (which were used to measure gait ability) after treatment were statistically greater in the treatment group. Another study that [82] involved 80 post-stroke hemiplegia patients with balance impairment found that the BBS scores in the Tai chi pile work group was higher than those in the rehabilitation group after 12 weeks of training.

5.2 Reduce Risk of Falls

A randomized controlled trial [83] conducted by Piliae RE et al. suggested that a 1-h class 3 times weekly of Yang style 24-posture short-form Tai chi over 12 weeks (the most common style) reduced fall rates compared to post-stroke patients who practiced strength exercise, range of movement training, or routine care interventions. Tai chi subjects had two thirds fewer falls (5 falls) compared to those who practiced strength exercise and range of movement training (14 falls) and routine care (15 falls) groups. In addition, they concluded that Tai chi, strength exercise and range of movement training result in an improved aerobic endurance, and are suitable for community-based programs to help with stroke recovery and community reintegration.

5.3 Improve Quality of Life

In one study [84] of 18 first-stroke survivors, study group patients had to perform a 1 h twice per week for 12 weeks Tai chi exercise). They showed an improvement in the Duke Health Profile (a health status self-reported evaluate as four dimensions: symptom status and physical, social as well as emotional function such as general functioning and social functioning. In a Kim H et al. [81] study, the differences in the quality of life on the basis of the SF-36 scores for physical functioning, physical pain, ordinary health, vitality, and mental health classifications were significant for study group.

5.4 Effects on Depression

A study [85] that involved 68 post-stroke patients found that the experimental group (exercised 30 min at a time, twice per week, for 5 weeks with Tai chi which consisted of 10 different movements) demonstrated a statistically significant difference in Hamilton Depression Rating Scale scores. Therefore, the effects of setting Tai chi exercise were better than normal limbs exercise improving depression of patients after stroke.

Traditional Chinese training has an important role in improving physical function in post-stroke patients. However, there are some possible adverse events that may occur in this population including muscle problems, hypotension, and dizziness. A few people may report back, leg, or knee pain and there is an increased risk of an ankle sprain. Therefore, when we choose Chinese exercise for the rehabilitation of stroke patients, we should consider possible problems and use it properly.

6 Summary

Evidence strongly proves a positive role for physical training that involves exercise such as aerobic exercises, strength training (particularly involving the upper body), flexibility exercises, neuromuscular exercises, and/or traditional Chinese exercises for stroke survivors. Studies report that stroke patients can improve physiologically, psychologically, as well as their sensorimotor, strength, endurance, and functional influences from post-stroke training. Although more validation by randomized clinical trials and other properly designed studies are needed, this overview shows that stroke survivors should take part in a routine exercise during their post-stroke rehabilitation period.

Exercise training is a beneficial yet underused part of post-stroke care. The care and exercise that are provided to the patient after the stroke should contain exercise training suggestions to improve their overall health. These interventions may reduce the risk of future cardiovascular events such as another stroke and/or a myocardial infarction.

When studying the process of movement, we should always monitor various safety indicators of stroke patients. If any danger occurs, the test should be terminated immediately. Contraindications to exercise therapy of stroke include the following:

- Sustained blood pressure (BP) >185/110 Hg despite treatment;
- Platelet counts <100,000; hematocrit (HCT) <25%; glucose level < 50 or >400 mg/dL;
- Use of heparin within 48 h, a prolonged PTT, or an elevated INR;
- Rapidly improving symptoms;
- Prior stroke or head injury within 3 months;
- Prior intracranial hemorrhage;

- Major surgery in preceding 14 days;
- Minor stroke symptoms;
- Gastrointestinal bleeding in preceding 21 days;
- Recent myocardial infarction;
- Coma or stupor

With education and encouragement regarding the benefits of physical training after stroke and the development of suitable stroke programs in hospitals and communities, the ability to recruit individuals to post-stroke rehabilitation programs should improve. These programs, formulated by trained exercise professionals, should be supplied early after stroke, and should continue to be watched throughout to study their lifestyle-changing behaviors and effects on overall health.

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