

Effects of Task-Oriented Circuit Class Training on Walking Competency After Stroke

A Systematic Review

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Background and Purpose—There is increasing interest in the potential benefits of circuit class training after stroke, but its effectiveness is uncertain. Our aim was to systematically review randomized, controlled trials of task-oriented circuit class training on gait and gait-related activities in patients with stroke.

Methods—A computer-aided literature search was performed to identify randomized, controlled trials in which the experimental group received task-oriented circuit class training focusing on the lower limb. Studies published up to March 2008 were included. The methodological quality of each study was assessed and studies with the same outcome variable were pooled by calculating the summary effect sizes using fixed or random effects models.

Results—Six of the 445 studies screened, comprising 307 participants, were included. Physiotherapy Evidence Database scores ranged from 4 to 8 points with a median of 7.5 points. The meta-analysis demonstrated significant homogeneous summary effect sizes in favor of task-oriented circuit class training for walking distance (0.43; 95% CI, 0.17 to 0.68; $P < 0.001$), gait speed (0.35; 95% CI, 0.08 to 0.62; $P = 0.012$), and a timed up-and-go test (0.26; 95% CI, 0.00 to 0.51; $P = 0.047$). Nonsignificant summary effect sizes in favor of task-oriented circuit class training were found for the step test and balance control.

Conclusions—This meta-analysis supports the use of task-oriented circuit class training to improve gait and gait-related activities in patients with chronic stroke. Further research is needed to investigate the cost-effectiveness and its effects in the subacute phase after stroke, taking comorbidity into account, and to investigate how to help people maintain and improve their physical abilities after their rehabilitation program ends. (*Stroke*. 2009;40:2450-2459.)

Key Words: exercise therapy ■ physical fitness ■ rehabilitation ■ stroke ■ systematic review

Stroke is one of the leading causes of impairment and disability in the Western world.¹ The activity most affected by stroke is walking with as many as 80% of patients initially losing this ability.²⁻⁴ Stroke rehabilitation improves walking competency in terms of gait and gait-related activities, although most individuals are still significantly disabled beyond 6 months after stroke.^{3,4}

Recently, a prospective study in 205 young stroke victims demonstrated that approximately 21% of the patients experienced a significant decline of mobility between 1 and 3 years poststroke.⁵ Multivariate analyses showed that inactivity was the most significant determinant of this mobility decline.⁵ Several studies have described training programs to prevent inactivity and improve gait and gait-related activities in the chronic phase after stroke.⁵⁻¹⁹ In addition, a number of systematic reviews have shown that task specificity and intensity of training, in terms of hours of therapy, are the main determinants of functional improvement after stroke.^{5,7,20,21}

This is evident from the effectiveness and efficiency of “task-oriented” training, in which gait and gait-related tasks are practiced using a functional approach. Moreover, there is growing evidence that intensive, task-oriented practice can induce greater improvement in walking competency in people with stroke than usual practice.⁸ Recent studies suggest that the training can be organized as a circuit with a series of workstations providing opportunities for task-oriented practice.¹⁰ Task-oriented circuit class training satisfies at least 3 key features of an effective and efficient physical training program. First, by using different workstations, circuit class training allows patients to practice intensively in a meaningful and progressive way that suit to their individual needs.^{12,22} Second, circuit class training is an efficient use of therapist time in which patients actively engaged in task practice when compared with individual therapy.²² With that, circuit class training is potentially an effective method of cost saving to the healthcare system by reducing staff-to-patient ratios.¹²

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Third, circuit class training encompasses group dynamics that include peer support and social interaction.^{10,12} This peer support and social interaction may enhance attendance at classes and improve compliance with individual exercises, thus increasing the “dose” of training and therefore its effectiveness. Furthermore, the social interaction may bring its own psychosocial benefits, eg, increased confidence and improved mood.

Despite the number of studies dedicated to task-oriented circuit class training, a systematic review evaluating this promising type of intervention is lacking. The purpose of the present review was to systematically examine the effects of task-oriented circuit class training on gait and gait-related activities in patients with stroke.

Materials and Methods

Definitions

Stroke has been defined by the World Health Organization as a focal (or at times global) neurological impairment of sudden onset, lasting >24 hours or leading to death, with no apparent causes other than of vascular origin.²³

Gait-related activities have been defined as activities involving mobility-related tasks such as stair walking, turning, making transfers, walking quickly, and walking for specified distances.⁵ Task-oriented circuit class training was defined in the present review as therapy provided to >2 participants simultaneously, which involved a series of workstations focusing on gait practice and functional gait-related tasks. The workstations are organized as a circuit, and the exercise at each workstation had to be progressive, ie, increasing the number of repetitions completed at a workstation and/or increasing the complexity of the exercise performed at each station.¹⁶ Circuit class training allows staff-to-patient ratios to be lower than they are in individual physical therapy and enables a group of patients to exercise at different workstations simultaneously under the supervision of one or more therapists.¹⁰ No additional restrictions were applied for the control group of identified randomized, controlled trials (RCTs). However, none of these studies used a placebo as a way of control in included RCTs.

Study Identification

Potentially relevant literature was identified through computerized and manual searches. The following electronic databases were systematically searched by 2 independent researchers (M.V., L.W.): PubMed (MEDLINE; 1966 to March 2008), Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Physiotherapy Evidence Database (PEDro; March 2008), EMBASE (1988 to March 2008), SportDiscus (1949 to March 2008), and CINAHL (1982 to March 2008). The following MeSH headings and key words were used: stroke, cerebrovascular accident, cerebrovascular disorders, CVA (patient type), circuit training, circuit class, exercise, rehabilitation, physical therapy, task-oriented, task-related fitness (intervention type), gait, walking, strength, balance (outcome type), and randomized, controlled trial (study type). Bibliographies of review articles, empirical articles, and abstracts published in proceedings of conferences were also examined. In further iterations, references from retrieved articles were examined to identify additional relevant trials that met the inclusion criteria. Studies published in the period up to March 2008 were included if they met the following inclusion criteria: (1) participants were patients with stroke who were >18 years of age; (2) task-oriented circuit class training was applied focusing on the lower limb; (3) at least one of the study outcomes focused on gait-related activities; (4) the study was published in English, German, or Dutch; and (5) the study was an RCT. The databases were searched using a study identification strategy that was formulated in PubMed and

adapted to the other databases. The full search strategy is available on request from the first author. Selection was first based on title and abstract, in which after the full-text articles were screened. In case of disagreement of the selection, the third independent researcher (I.v.d.P.) was asked to make the final decision.

Methodological Quality

Two independent reviewers (M.V., G.K.) assessed the methodological quality of each RCT using the PEDro scale^{24,25} (Table 1); however, during this assessment, the reviewers were not blinded to authors, journals, and outcomes. PEDro is an 11-item scale, in which the first item relates to external validity and the other 10 items assess the internal validity of a clinical trial. One point was given for each criterion that was satisfied (except for the first item, which was allocated a YES or NO), yielding a maximum score of 10. The higher the score, the better the quality of the study. PEDro scores of ≥ 4 points were classified as “high quality,” whereas studies with ≤ 3 points were “low quality.”⁷ A point for a particular criterion was awarded only if the article explicitly reported that the criterion had been met.²⁵ In case of disagreement, consensus was sought, but when disagreement persisted, a third independent reviewer (I.v.d.P.) made the final decision.

Quantitative Analysis

The extracted data (numbers of patients in the experimental and control groups, mean difference in change score, and SD of the outcome scores in the experimental and control groups at baseline) were checked independently by 2 reviewers and entered into Excel for Windows. For outcome variables, we combined results by calculating standardized mean difference and 95% CIs. The standardized mean difference for each study was assessed by calculating the difference in postintervention means between the experimental and the control groups divided by the pooled SD_i of each experimental and control group.^{26,27} Pooled SD_i were calculated by extracting the SDs of postintervention scores of experimental and control groups for each study. If necessary, means and SD_i were requested from the authors. Subsequently, standardized mean differences were pooled to obtain a weighted overall or summary effect size (SES). Finally, the weights of all studies were combined to estimate the variance of the SES.²⁸ SES was expressed as the number of SD units (SDUs) and a CI. The fixed effects model was used to decide whether an SES was statistically significant. The homogeneity (or heterogeneity) test statistic (Q statistic) of each set of effect sizes was examined to determine whether studies shared a common effect size, which would allow the variance to be explained by sampling error alone.^{29,30} Because the Q statistic underestimates the heterogeneity in meta-analysis, the percentage of total variation across the studies was used by calculating I^2 , which gives a better indication of the consistency between trials.³¹ If significant heterogeneity was found (I^2 values >50%),³¹ a random effects model was applied.²⁹ In case of statistical heterogeneity, a sensitivity analysis was considered for methodological quality of included studies with respect to randomization, allocation concealment, blinding of final outcome assessment, and presence of intention-to-treat analysis.

For all outcome variables, the critical value for rejecting H_0 was set at a level of 0.05 (2-tailed). On the basis of the classification by Cohen, effect sizes <0.2 were classified as small, those from 0.2 to 0.8 as medium, and those >0.8 as large.³⁰

Results

Study Identification

The initial search strategy resulted in a list of 445 relevant citations. After selection based on title and abstract, we excluded 428 studies; reasons for exclusion included studies not using randomization, using an intervention that did not fit

Table 1. Characteristics of the Studies Included in the Review

Study (year of publication)	No. (E/C)	Time Since Stroke (mean no. of days at inclusion)	Intensity (I) Progression (P)	Workstations Applied in Experimental Group, Therapy of Control Group
Dean et al ¹⁰ (2000)	12 (6/6)	>3 months (658)	I: 4 weeks; 3 times a week; 60 minutes I: 10 workstations, 5 minutes each P: increasing number of repetitions P: increasing complexity of workstations	E: (1) Sitting at a table and reaching in different directions for objects located beyond arm's length to promote loading of the affected leg and activation of affected leg muscles; (2) Sit-to-stand from various chair heights to strengthen the affected leg extensor muscles and practice this task; (3) Stepping forward, backward, and sideways onto blocks of various heights to strengthen the affected leg muscles; (4) Heel lifts in standing to strengthen the affected plantar flexor muscles; (5) Standing with the base of support constrained with feet in parallel and tandem conditions reaching for objects, including down to the floor, to improve standing balance; (6) Reciprocal leg flexion and extension using the Kinetron in standing to strengthen leg muscles; (7) Standing up from a chair, walking a short distance, and returning to the chair to promote a smooth transition between the 2 tasks; (8) Walking on a treadmill; (9) Walking over various surfaces and obstacles; (10) Walking over slopes and stairs C: Both a circuit component with subjects completing practice at a series of workstations (eg, wrist extension, supination, grasp, and release of various objects) and some exercises completed in small groups
Blennerhasset et al ⁴¹ (2004)	30 (15/15)	Subacute (43) Blinded observer	I: 4 weeks; 5 times a week; 60 minutes I: 10 workstations, 5 minutes each P: suited to individual subjects	E: Endurance tasks using stationary bikes and treadmills; Functional tasks such as sit-to-stand, stepups, obstacle course walking, standing balance, stretching as required Strengthening using traditional gymnasium equipment C: Functional tasks to reach and grasp, hand-eye coordination activities, stretching as required; Strengthening using traditional gymnasium equipment
Salbach et al ⁸ (2004)	91 (44/47)	Chronic (228) Blinded observer	I: 6 weeks; 3 times a week; approximately 60 minutes I: 10 workstations, 5 minutes each, 1 for 10 minutes (treadmill) P: increasing the duration of workstations P: increasing the level of difficulty in each task	E: (1) Stepups; (2) Balance beam; (3) Kicking ball; (4) Standup and walk; (5) Obstacle course; (6) Treadmill; (7) Walk and carry; (8) Speed walk; (9) Walk backwards; (10) Stair walking C: Functional upper extremity tasks such as manipulating cards, using a keyboard, and writing
Pang et al ¹⁸ (2005)	63 (32/31)	>1 year (1881) Blinded observer	I: 19 weeks; 3 times a week; 60 minutes I: 3 workstations P: 10 minutes initially, with increment of 5 minutes every week, up to 30 minutes P: progressive exercise intensity increment of 10% HRR every week P: increasing number of repetitions	E: (1) Cardiorespiratory fitness and mobility (brisk walking, sit-to-stand, alternate stepping onto low risers); (2) Mobility and balance (walking in different directions, tandem walking, walking an obstacle course, sudden stops and turns during walking, walking on different surfaces (carpet, foam), standing on foam, balance disc, or wobble board, standing with one foot in front of the other, kicking ball with either foot); (3) Leg muscle strength (partial squats, toe rises) (1) Shoulder muscle strength (resistance band exercises); (2) Elbow/wrist muscle strength and range of motion (dumbbell/wrist cuff weight exercises, passive or self-assisted range of motion to paralyzed joints, upper extremity weightbearing on physio ball); (3) Hand activities (hand muscle strengthening exercises using putty and grippers, playing cards, picking up objects of various sizes and shapes, electrical stimulation)

the previously described definition of circuit class training, or being conducted in a different patient population (Figure 1). Seventeen full-text articles were selected, 6^{32–37} of which were excluded because the intervention did not meet the inclusion criteria. Two^{12,38} more were excluded because the

studies were not RCTs. Another 2 studies^{39,40} were excluded because the outcome type was not gait-related. One study¹⁵ was excluded because it involved a secondary analysis of another included trial.⁸ Screening of references did not lead to other studies being included.

Table 1. Continued

Activities Besides Workstations	Patients per Group	Dropouts (D) Attendance at the Training (A)	No. of Therapists Attending	Outcome	Author's Conclusion
10 minutes participating in walking relays and races	6	D=3 1 (E) and 1 (C) before training (1C) after the training as a result of medical condition unrelated to training A: was not described	2 physiotherapists	6MWT, gait speed, TUG, step test, sit-to-stand	This task-related circuit training improved locomotor function in chronic stroke; walking distance, gait speed, and the step test showed significant improvements in the experimental group
Warmup	Up to 4	D=0 1 was not tested at 6 months A: 100%	1 physiotherapy department staff member	6MWT, TUG, step test, upper limb function (MAS, JTHFT)	Findings support the use of additional task-related practice during inpatient stroke rehabilitation; the mobility group showed significantly better locomotor ability than the upper limb group; the circuit class format was a practical and effective means
Warmup	?	Attendance at the training (A) D=7 3 (E) discontinued intervention 4 (C) discontinued intervention A: 1718 of 18 treatment sessions for E and C	1 physical or occupational therapist	6MWT, gait speed, TUG, balance (BBS)	The task-oriented intervention significantly improved walking distance and gait speed
?	9 to 12	D=3 2 (E) discontinued intervention 1 (C) discontinued intervention A: E 81.4% C 80.4%	1 physical therapist, 1 occupational therapist, and 1 exercise instructor	6MWT, balance (BBS), leg muscle strength, endurance, physical activity (PAS)	The intervention group had significantly greater gains in cardiorespiratory fitness, mobility, and paretic leg strength

(Continued)

In total, therefore, 6 studies^{8,10,16-18,41} were included in this systematic review, comprising 307 participants, of whom 152 were randomized to the task-oriented circuit class training. The control group received training of the upper extremity in

48,10,18,41 studies; one study provided a seated relaxation intervention, including deep breathing exercise,¹⁷ and the other study provided no rehabilitation training at all.¹⁶ Sample sizes ranged from 9¹⁰ to 91⁸ participants. Time between

Table 1. Continued

Study (year of publication)	No. (E/C)	Time Since Stroke (mean no. of days at inclusion)	Intensity (I) Progression (P)	Workstations Applied in Experimental Group, Therapy of Control Group
Yang et al ¹⁶ (2006)	48 (24/24)	>1 year (1927) Blinded observer	I: 4 weeks; 3 times a week; 30 minutes I: 6 workstations, 5 minutes each P: increasing the number of repetitions completed in 5 minutes at a workstation P: increasing complexity of exercises	E: (1) Standing and reaching in different directions for objects located beyond arm's length to promote loading of the lower limbs and activation of lower limb muscles; (2) Sit-to-stand from various chair heights to strengthen the lower limb extensor muscles; (3) Stepping forward and backward onto blocks of various heights to strengthen the lower limb muscles; (4) Stepping sideways onto blocks of various heights to strengthen the lower limb muscles; (5) Forward stepup onto blocks of various heights to strengthen the lower limb muscles; (6) Raising and lowering heel(s) while maintaining a standing posture to strengthen the plantar flexor muscles C: No rehabilitation training
Mead et al ¹⁷ (2007)	66 (32/34)	2–10 months (159)	I: 12 weeks; 3 times a week P: 15 minutes at Week 1 increasing to 40 minutes at Week 12 P: cycle intensity was increased in pedaling resistance, cadence while maintaining perceived rate of exertion in the range 13 to 16 P: increasing the number of repetitions during resistance training	E: Endurance training: (9 minutes to 21 minutes at Week 12) (1) Cycle ergometry; (2) Raising and lowering a 1.4-kg, 55-cm exercise ball; (3) Shuttle walking; (4) Standing chest press; (5) Stairclimbing and descending exercise (added in Week 4) C: Resistance training: (1) Upper back strengthening and triceps extension exercise, both performed seated using elastic resistance training bands; (2) Pole-lifting performed standing; (3) Sit-to-stand exercise Seated relaxation intervention, including deep breathing and progressive muscular relaxation (20 minutes to 49 minutes at Week 12)

E/C indicates experimental versus control group; E, experimental group; C, control group; MAS, modified Ashworth scale; JTHFT, Jebsen Taylor hand function test; PAS, Physical Activity Scale; SF-36, Social Functioning 36.

stroke onset and the start of the intervention ranged from a mean of 43 days⁴¹ to more than 5 years.¹⁶ Table 1 shows the main characteristics of the included studies.

Methodological Quality

PEDro scores ranged from 4 to 8 points with a median score of 7.5 points (Table 2). All studies, except the study by Dean et al,¹⁰ scored at least 7 points on the PEDro scale. As expected, none of the studies had therapists blinded to group allocation, because the therapists had to administer the therapy. All studies applied statistical analysis to group differences and reported point estimates and measures of variability. Outcome assessments were performed by an assessor who was blinded to group allocation in all studies, except in the trial by Dean et al.¹⁰

Quantitative Analysis

Pooling of outcomes was possible for (1) walking distance; (2) gait speed; (3) timed up-and-go test (TUG); (4) step test; and (5) balance. One study¹⁷ did not report baseline SDs, so means and SDs were obtained from the author.

Walking Distance

Five studies^{8,10,16,18,41} (n=241) evaluated the effect of task-oriented circuit training on walking distance. All studies assessed walking distance by the 6-minute walk test (6MWT).⁴² Pooling individual effect sizes revealed a significant homogeneous SES (SES [fixed], 0.43 SDU; 95% CI, 0.17 to 0.68; Z=3.26; P<0.001; I²=34.7%; Figure 2).

Gait Speed

Four studies^{8,10,16,17} (n=214) assessed the effect of task-oriented circuit training on gait speed. Gait speed was measured over distances ranging from 5 m to the mean speed achieved in at least 3 minutes. A significant homogeneous SES was found compared with the control groups (SES [fixed], 0.35 SDU; 95% CI, 0.08 to 0.62; Z=2.51; P=0.012; I²=0%; Figure 2).

Timed Up-and-Go Test

Five studies^{8,10,16,17,41} (n=244) investigated the effects of task-oriented circuit training on the TUG. TUG was performed in the same way in all studies using the method described by Podsiadlo and Richardson.⁴³ A significant homogeneous SES was found in favor of circuit class training when compared with control groups (SES [fixed], 0.26 SDU; 95% CI, 0.00 to 0.51; Z=1.99; P=0.047; I²=0%; Figure 2).

Balance

Three studies^{10,16,41} (n=87) evaluated the step test. The step test is used to evaluate the ability of the affected lower limb to support and balance the body mass while stepping with the unaffected limb and is considered to be a valid and reliable measurement of dynamic standing balance. A nonsignificant homogeneous SES was found in favor of those patients who received circuit class training (SES [fixed], 0.37 SDU; 95% CI, -0.06 to 0.80; Z=1.70; P=0.089; I²=0%; Figure 2). All

Table 1. Continued

Activities Besides Workstations	Patients per Group	Dropouts (D) Attendance at the Training (A)	No. of Therapists Attending	Outcome	Author's Conclusion
	?	D=none A=100%	1 physical therapist	6MWT, gait speed, cadence, stride length, TUG, step test, muscle strength	The experimental group showed significant improvement in all selected measures of functional performance, except for the step test; lower extremity muscle strength also significantly improved in the experimental group; the strength gain was significantly associated with gain in functional tests
Warmup (10–15 minutes); Graded cool-down and standing stretches Cool-down and flexibility exercises (10–15 minutes)	Up to 7	D=1 A: Full attendance in 59% of E 59% and 50% of C Of 1152 scheduled exercise sessions, 933 were attended; of the 1224 relaxation sessions, 998 were attended; the time of absences was variable but infrequent	1 advanced exercise instructor	Gait speed, TUG, sit-to-stand, Functional Independence Measure (FIM), Nottingham Extended Activities of Daily Living (NEADLs), Rivermead Mobility Index (RMI), functional reach, Elderly Mobility Scale (EMS), SF-36 Questionnaire, Hospital Anxiety and Depression Score (HADS), walking economy (oxygen uptake)	Exercise training for ambulatory stroke patients was feasible and led to significantly greater benefits in aspects of physical function and perceived effect of physical health on daily life At 3 months, role-physical (an item in SF-36), TUG, and walking economy were significantly better in the exercise group (analysis of covariance); at 7 months, role-physical was the only significant difference between groups

studies performed the step test using the method described by Hill et al.⁴⁴

Two studies^{8,18} (n=154) assessed balance after intervention using the Berg Balance Scale (BBS).⁴⁵ A nonsignificant homogeneous SES was found for BBS (SES [fixed], 0.25 SDU; 95% CI, -0.14 to 0.49; Z=1.09; P=0.276; I²=0%; Figure 2).

Discussion

This systematic review demonstrated medium-sized, statistically significant effects in favor of task-oriented circuit class training for walking distance and gait speed and the TUG. No statistically significant effects were found for the step test or balance control measured by the BBS. Five of the 6 identified trials demonstrated sufficient methodological quality. The significant SES of walking distance is equivalent to a mean improvement of 42.5 m on the 6MWT and a mean improvement of 0.07 m/s in gait speed. This observed effect is similar to the effect seen when individual gait-oriented training is given.⁵ Future studies should increase the dose of training and determine the clinical implication of these changes in favor of group training. It should be noted, however, that gait speed is a responsive measure^{46,47} that validly reflects of progress in the recovery of poststroke mobility.^{48,49} On the other hand, gait speed over a short distance tends to overestimate locomotor competency after stroke,⁵⁰ whereas an improved gait speed does not automatically result in increased walking distances and hence in the level of community ambulation attained.⁵¹

No significant effects were found on balance control as measured with the step test⁴⁴ as well as measured by the BBS, which was measured in 2 studies.^{8,18} Most patients recruited for circuit class training show relatively high scores on the BBS at baseline, which limits further significant change on this scale.⁵² This finding is in agreement with those of Mao et al,⁵³ who demonstrated that the BBS has good responsiveness before 90 days after stroke onset but shows ceiling effects and hence a low responsiveness in later stages after stroke. In the 2 studies that assessed balance control with the BBS, the mean numbers of days after stroke onset were 228⁸ and 1881,¹⁸ respectively.

This systematic review suggests that circuit class training may be more beneficial if it is provided in the (sub)acute phase of the patient's rehabilitation rather than in the chronic phase.^{20,54} All the included studies recruited patients who were in a chronic stage after stroke, except for the study by Blennerhassett et al⁴¹ (mean time from stroke to inclusion was 43 days). Blennerhassett and colleagues⁴¹ found larger effects on walking distance, TUG, and the step test than the other trials, suggesting that perhaps training might be more effective if provided earlier after stroke onset.

Several trials^{10,17,41} showed that the benefits of training were lost after the exercise sessions stop. For example, Blennerhasset et al⁴¹ demonstrated that all mobility measures (6MWT, TUG, and the step test) deteriorated in 2 of 15 subjects allocated exercise and the 6MWT distance deteriorated by >15% in 5 subjects 5 months after the interventions

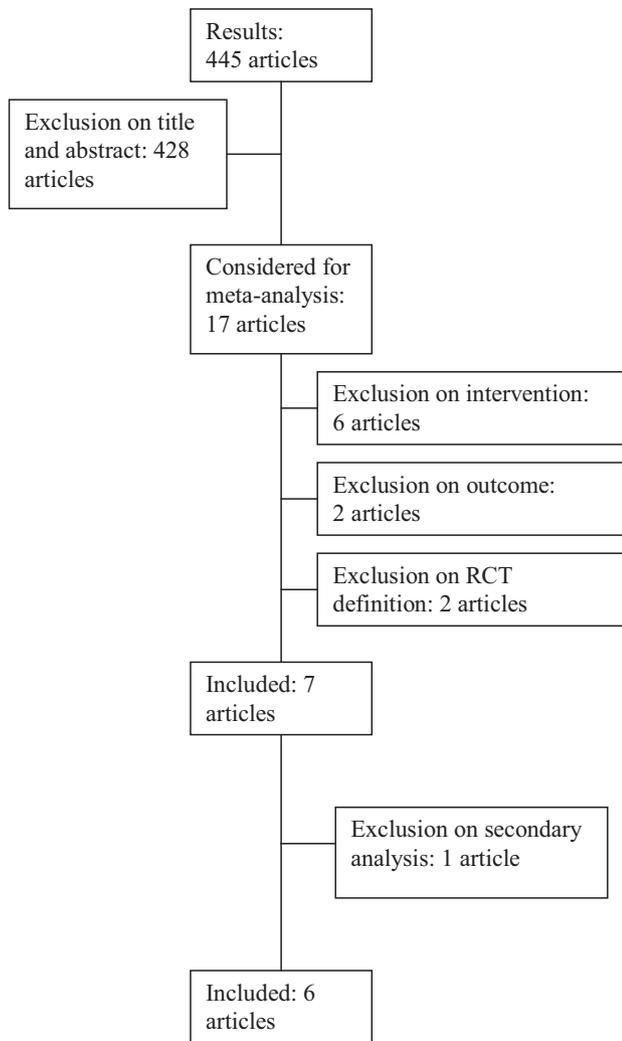


Figure 1. Inclusion and exclusion criteria for the present review.

had been completed. Mead et al¹⁷ reported that at 7-month follow-up (ie, 4 months after the interventions had been completed), almost all significant improvements in the experimental group had disappeared, suggesting that exercise should be continued on a regular basis after circuit class training.⁵⁵

Ongoing participation in physical activity may also improve vascular risk factors and so reduce the risk of coronary heart diseases and recurrent strokes.^{56,57} For example, meta-analysis⁵⁸ has demonstrated that increased physical activity improves cardiac performance and exercise capacity in patients with heart failure. In this systematic review, patients

were excluded if they had any medical condition that would prevent participation in a training program.^{8,10,16,41} Pang et al¹⁸ and Mead et al¹⁷ described more precisely contraindications to exercise. Pang et al¹⁸ precluded subjects with histories of serious cardiac disease (eg, myocardial infarction, uncontrolled blood pressure) and Mead et al¹⁷ excluded patients with uncontrolled angina pectoris, resting systolic blood pressure >180 mm Hg or resting diastolic blood pressure >100 mm Hg, resting heart rate >100 beats/min, unstable or acute heart failure, uncontrolled visual, or vestibular disturbance.

There is currently variation in documented medical contraindications to exercise after stroke. In exercise services currently being developed in Scotland, exercise instructors are applying the contraindications used by Mead et al¹⁷ (G. Mead, personal communication), whereas the American Heart Association recommends treadmill testing for every subject before participating in an exercise training program after stroke to identify undiagnosed cardiac disease.⁵⁹ This systematic review suggests that circuit class training seems to be safe for patients with stroke, although none of the included studies systematically reported complications such as recurrent strokes, cardiac problems, or other exercise-related injuries such as falls. Clarification of the risks of exercise after stroke, and medical contraindication to exercise, would help in the design of future exercise services and exercise trials.

Task-oriented circuit class training holds great potential for the rehabilitation of people after stroke. First, workstations of circuit class training can be customized to the individual status of each participant, including the intensity, frequency, and duration of the exercises, which is important for walking endurance.⁸ In this systematic review, the progression during the circuit class training differed between studies in terms of increasing the number of repetitions,^{10,16–18} increasing the duration of exercise at each workstation,^{8,17,18} or increasing the complexity of exercises.^{8,10,16} Blennerhasset et al⁴¹ mentioned that the workstations were progressed to suit individual subjects but did not describe in what way. Second, in all included studies,^{8,10,16–18,41} the proportion of the total number of classes attended was generally high and was reported as 80% to 100%. Third, circuit class training may be more cost-effective than individual physical therapy sessions.¹² Only one or 2 therapists needed to attend each group session in the studies included in our review, and the number of patients per session ranged from 4⁴¹ to 12.¹⁸ The cost-effectiveness of intensive exercise training on quality of life in patients who experience the consequences of

Table 2. PEDro Scores for Each RCT

Study	1	2	3	4	5	6	7	8	9	10	11	Total Score
Dean et al ¹⁰	Yes	1	1	0	0	0	0	0	0	1	1	4
Blennerhasset et al ⁴¹	Yes	1	1	1	0	0	1	1	1	1	1	8
Salbach et al ⁹	Yes	1	1	1	0	0	1	1	1	1	1	8
Pang et al ¹⁸	Yes	1	1	1	0	0	1	1	1	1	1	8
Yang et al ¹⁶	Yes	1	1	1	0	0	1	1	0	1	1	7
Mead et al ¹⁷	Yes	1	1	1	0	0	1	1	1	1	1	8

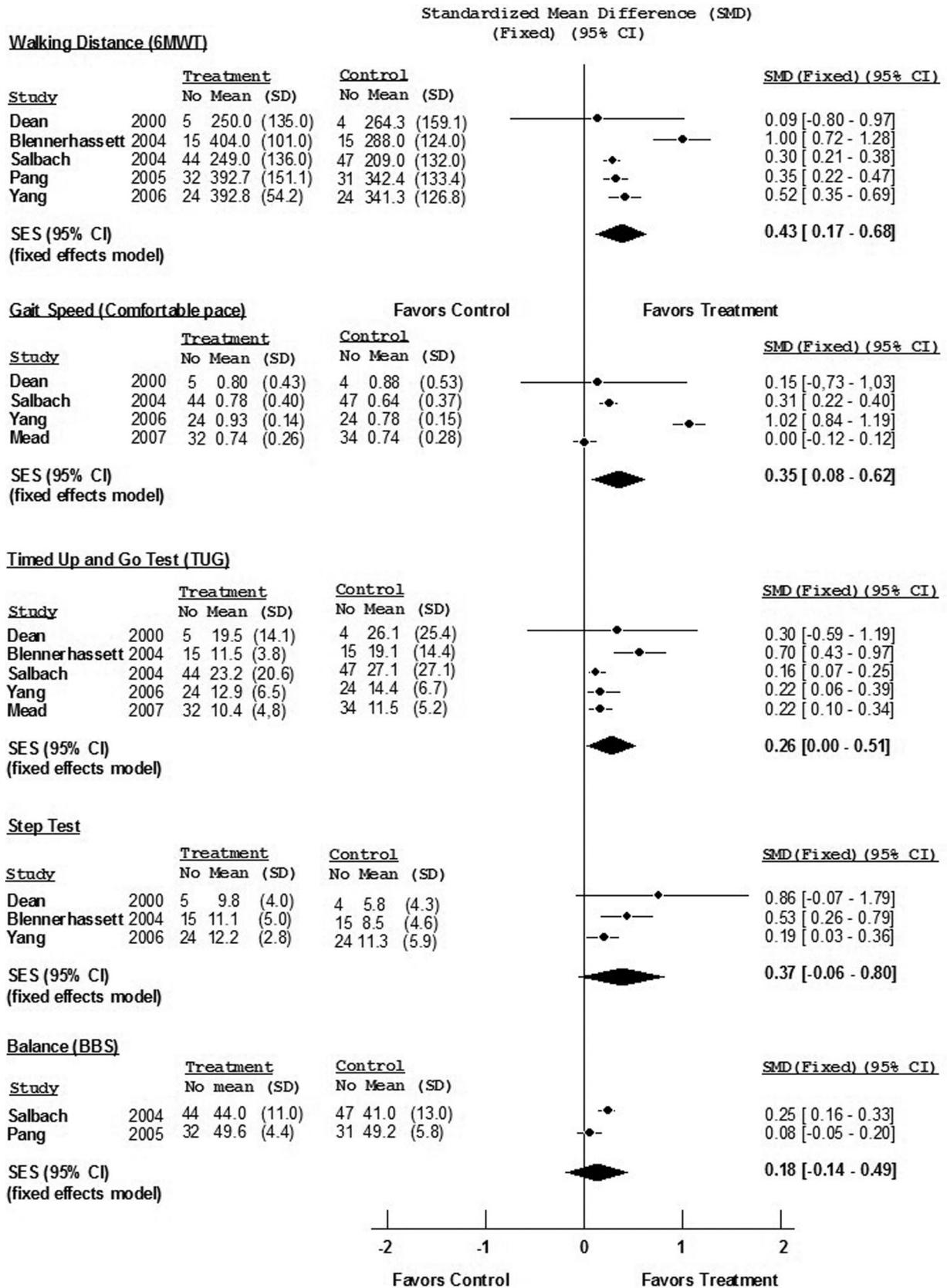


Figure 2. Meta-analysis of task-oriented circuit class training trials measuring walking distance, gait speed, TUG, step test, and balance (mean and 95% CI). The SES value represents the overall effect size of all included studies per outcome.

stroke, including those with residual gait problems, is seen by the American Heart Association as the major challenge for future research to overcome the increasing costs of stroke care.⁹

Although this systematic review aimed to identify all relevant trials, there are some limitations. First, the review did not include RCTs published in languages other than English, German, or Dutch. Second, the number of studies of task-oriented circuit class therapy after stroke has so far been limited. Third, we cannot rule out publication bias. In particular, small RCTs with none significant or inconclusive results are less likely to be submitted or accepted for publication in the literature.⁶⁰ Fourth, 4^{8,10,18,41} of the 6 studies provided training of the upper extremity to patients in the control group, which may have diluted treatment effects. Another limitation of our review is that the content of the exercise intervention varied substantially among the RCTs with important differences in the aims of applied workstations and used equipment such as treadmills, intensity, start and progression of the circuit class training program, and staff-to-patient ratios. Unfortunately, the small statistically homogeneous number of studies in the field of circuit class training did not allow us to apply a sensitivity analysis to explore these factors.

None of the studies included in this review estimated the cost-effectiveness of circuit class training when compared with usual face-to-face physical therapy as recommended by various councils of the American Heart Association,⁹ acknowledging that most of these trials recruited people after their normal rehabilitation had been completed and not as a replacement for the usual received care. Further studies are needed to compare the cost-effectiveness of this service model with that of usual care¹² acknowledging that lack of time and lack of staff are major barriers to the implementation of intensive practice after stroke.⁶¹ In addition, randomized clinical trials should preferably start early after stroke onset, increase the dose of training, and further underpin the clinical meaning of these changes in favor of group training. Comorbidity needs to be considered, and future trials should investigate how to facilitate lifelong participation in physical exercise. A single-blinded randomized clinical trial is currently being conducted in 10 rehabilitation centers in The Netherlands. The primary aim of this multicenter trial, with the acronym "FIT-Stroke," is to determine the effectiveness in terms of domain mobility of the Stroke Impact Scale (SIS Version 3.0) and cost-effectiveness evaluated by the EuroQol (EQ-5D) of task-oriented circuit class training when compared with individual care in patients who are discharged from a rehabilitation center for further therapy in the community. The first results are expected in August 2011.

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Disclosures

None.

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