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Analytical Review

Effectiveness of Circuit-Based Exercises on Gait Speed, Balance, and Functional Mobility in People Affected by Stroke: A Meta-Analysis

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Abstract

Background: Several interventions have been proposed to rehabilitate patients with neurologic dysfunctions due to stroke. However, the effectiveness of circuit-based exercises according to its actual definition, ie, an overall program to improve strength, stamina, balance or functioning, was not provided.
Objective: To examine the effectiveness of circuit-based exercise in the treatment of people affected by stroke.
Methods: A search through PubMed, Embase, Cochrane Library, and Physiotherapy Evidence Database databases was performed to identify controlled clinical trials without language or date restriction. The overall mean difference with 95% confidence interval was calculated for all outcomes. Two independent reviewers assessed the risk of bias.
Results: Eleven studies met the inclusion criteria, and 8 presented suitable data to perform a meta-analysis. Quantitative analysis showed that circuit-based exercise was more effective than conventional intervention on gait speed (mean difference of 0.11 m/s) and circuit-based exercise was not significantly more effective than conventional intervention on balance and functional mobility.
Conclusion: Our results demonstrated that circuit-based exercise presents better effects on gait when compared with conventional intervention and that its effects on balance and functional mobility were not better than conventional interventions.
Level of Evidence: I

Introduction

Stroke is one of the world's leading causes of death and physical and cognitive sequelae, affecting 16 million people and causing 6 million deaths/year. In Brazil, it was estimated that 2,231,000 suffered from stroke incapacities, mostly middle-aged adults and elderly people, and 568,000 of those presented severe disabilities [1]. Different types of stroke can cause different degrees of dysfunction, such as difficulty in accomplishing daily living activities, learning, maintaining body position, posture transfer, gait, balance, and social factors like interpersonal interactions [2]. In this sense, several interventions are proposed for the rehabilitation of patients with stroke sequelae that vary from muscle and isolated segment exercises by passive kinesiotherapy to active intervention such as resistance exercises [3], motor imagery [4], walking training [5], virtual reality [6], practice-oriented tasks [7]. and circuit-based activities [8].

With respect to circuit-based exercises (CBEs), it currently is possible to identify the existence of 3 systematic reviews that assessed the effectiveness of CBEs on individuals with stroke. Two studies conducted by the same authors (a systematic review and a systematic review with meta-analysis published in different journals) used the term circuit class therapy to assess the effectiveness of circuit exercises to improve mobility of adults after a stroke and presented similar results [9]. The definition of circuit class therapy was: Task-oriented circuit class training defined as therapy provided to more than 2 participants simultaneously, which

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involved a series of workstations focusing on gait practice and functional gait-related tasks. These studies concluded that circuit class therapy is effective in improving mobility in stroke patients.

The third study, a systematic review with meta-analysis, showed the possibility of using task-oriented circuit class training to improve gait and gait-related activities of patients with chronic stroke. In this study, the definition of task-oriented circuit class was: Task-oriented approaches using a training program that focuses on specific functional tasks and is patient-centered [10].

The term CBE or circuit training was introduced in Medical Subject Headings ([MeSH] available at: https://www.ncbi.nlm.nih.gov/mesh/) at the end of 2015. According to MeSH, a CBE must be "an alternate set of exercises that works out different muscle groups and that also alternates between aerobic and anaerobic exercises, which, when combined together, offer an overall program to improve strength, stamina, balance, or functioning." According to this definition, one could notice that the aforementioned systematic reviews used different concepts to define CBE when providing evidence. Moreover, the workstation was focused on gait practice, functional gait-related tasks, and specific functional tasks. Therefore, other approaches such as aerobic and anaerobic exercises in different muscle groups (eg, whole body and upper limbs) were not included into the circuit exercises of the systematic reviews cited. In addition, the most recent of those reviews was published in 2010 (last search October 2009).

Considering these relevant factors, the need of an adequate CBE definition to provide evidence about its effectiveness, and regarding the date of publication of the related articles, the objective of this study was to conduct a systematic review to examine the effectiveness of CBE in the treatment of patients with stroke.

Methods

This systematic review was performed according the PICO acronym: Population: stroke patients; Intervention: CBE; Comparator: conventional therapy or no intervention; Outcomes: variables related to body physical-function such as muscle strength, gait, balance and mobility. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis available at http://www.prisma-statement.org was used as the checklist document.

Search Methods to Identify the Studies

Two independent authors performed an electronic search between November 2016 and March 2017 at PubMed, EMBASE, Cochrane Library, and Physiotherapy Evidence Database (PEDro) databases and used the following keywords and search strategy: (1) ("Circuit-based Exercise" OR "Multi-modal Exercises" OR "Circuit Training" OR "Multisensory Training"); (2) ("Circuit-based Exercise" OR "Multi-modal Exercises" OR "Circuit Training" OR "Multisensory Training") AND ("Stroke" OR "Cerebrovascular Accident"). There was no language or year restriction.

Selection Criteria

The inclusion criteria were decided by consensus between the authors: (1) following the Cochrane Collaboration Handbook recommendations, only randomized clinical trials were included; (2) studies with participants $\geq$18 years old diagnosed with stroke; (3) studies that clearly described the CBE in the experimental group according to MeSH definition (an alternate sets of exercise that works out different muscle groups and that also alternates between aerobic and anaerobic exercises, which, when combined together, offer an overall program to improve strength, stamina, balance, or functioning); (4) all others interventions (comparative groups) compared with CBE must be conventional therapy (eg, physical therapy) or no intervention. The exclusion criteria were CBE performed with another intervention (concurrent therapy) and participants with neurological comorbidities (eg, Alzheimer disease).

Study Selection

Articles were selected after a sequenced reading of the title, abstract, and full text, always in this order. First, the titles retrieved in the search, then the abstract, which showed relevance with the theme, and finally the methodologic analysis of CBE used in the selected studies. Divergence in study selection was resolved by consensus between the reviewers. The reference list of the articles was consulted to find possible additional studies. Duplicated items after the search were removed.

Data Extraction

Data collected were authors, year, study design, population and recruitment, number of participants, age, CBE description and control groups, assessment protocol, and outcomes.

Methodologic Quality Assessment

The methodologic quality of the identified randomized controlled trials was scored via the PEDro scale, which presents 11 items (random allocation; concealed allocation; baseline comparability; blind subjects; blind therapists; blind assessor; adequate follow-up; intention-to-treat-analysis; between groups comparisons; point estimates; and variability) rated as "yes" or "no." The first item is not used to calculate the score; thus, it ranges from 0 to 10 points. Trials with a PEDro score $\geq$6 points were classified as high quality, whereas trials with a PEDro score $<$6 points were classified as low quality. The assessment of selected studies was performed according to Brazilian-Portuguese version of the PEDro scale [11].

Risk of Bias

The risk of bias of individual articles (as well as articles included in the meta-analysis) was assessed through the risk of bias guide from the Cochrane Handbook for Systematic Review of Interventions [12]. The guide consists of 7 items: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other biases. Each item can be categorized as "high risk," "low risk," or "unclear risk."

Statistical Analysis

For the meta-analysis, the outcome measures were closest to the last time point measurement, even if the studies used various time point measurements. Therefore, the last postintervention measurement was chosen for analysis. Data required to enter into RevMan (Version 5.3; Copenhagen: The Nordic Cochrane Centre) to calculate the standardized mean difference (SMD) or mean difference (MD) for continuous outcomes were as follows: (1) mean change in variable "X" from baseline to last point outcome measure (LPM); (2) standard deviation (SD) of the MD in variable "X"; and (3) number of participants ("n") in each group. To calculate the mean change in a variable from baseline to follow-up, we used the MD: mean value at LPM minus mean at baseline (process in all comparison groups). The SD of the MD in each group was calculated as follows: standard error (SE) difference= $\sqrt{}$ [$SD_1{}^{2}/n_1 + SD_2{}^{2}/n_2$], where SD_1 is the SD at baseline, n_1 is the number of participants at LPM; SD_2 is the SD at follow-up, and n_2 is the number of participants at baseline. Finally, to calculate the SD difference from the SE difference, we used SE $=$ SD $\sqrt{n}$; thus, SD difference $=$ SE difference X $\sqrt{n}$.

Regarding gait speed and considering that it was measured across studies in several ways (6-Meter Walk Test [seconds], 2-Meter Walk Test [seconds], 5-Minute Walk Test [meters], comfortable walking [m/s]), the results of the studies were converted into a uniform scale before the meta-analysis. The measurements of these gait tests were given in distance (meters), time (seconds), and speed (meters/second and centimeters/second). All the values were standardized in speed (meters/second), using the simple equation: $v = \Delta x / \Delta t$, where "v" indicates velocity, "Δx" indicates distance variation, and "Δt" indicates time variation. Considering this procedure, the MD and the 95% confidence interval [CI] were considered in the meta-analysis [12,13] of the gait speed. Considering that functional mobility (Timed Up and Go Test) and balance (Berg Balance Scale) used the same unit and scales, the MD and the 95% CI were considered in the meta-analysis [12,13].

The fixed-effects model was used when the results were homogeneous ($P > .10$), and the random-effects model was used when heterogeneity was confirmed; this was applied in all analyses [14]. The statistical analysis was performed using the Review Manager software, RevMan, version 5.3.

Results

Included Studies

The electronic search retrieved 159 articles, of which 47 were excluded as duplicates, 39 for not meeting the objective of the present study, and 3 systematic reviews. On the assessment of eligibility, 12 were excluded: 2 did not meet the MeSH description of CBE, 4 poorly described how the circuit worked, 1 associated the intervention with functional electric stimulation while the participants were performing the CBE, 1 used only a resistive exercises circuit, 1 had no randomization, 3 did not describe the results properly (SD difference for meta-analysis), and in the last one, no answer were received from 3 authors to find out more information. Therefore, 11 RCTs were included in the systematic review. Figure 1 shows the flow of search process and the included studies in the qualitative ($n = 11$) and quantitative ($n = 8$) analyses.

In the presence of inadequate information about the primary outcomes, the authors of the studies were contacted to provide additional information. However, we received no answer.

General Characteristics of the Studies

Study characteristics are presented in Table 1 [15-23]. A sample of 750 participants aged between 38 and 91 years (63.40 [7.25]) participated in the studies. The time of stroke diagnosis in CBE groups ranged from 1.2 to 92.4 months (32.13 [30.94]) and in control groups ranged from 1.67 to 157.2 months (32.37 [45.24]). The overall period of therapeutic intervention (the same in 2 groups) ranged from 4 to 19 weeks (6.63 [4.7]). The frequency of intervention in CBE groups ranged from 2 to 7 times per week (4 [2.1]) and control groups ranged from 2 to 5 times per week (3.3 [1.1]). Duration of intervention (session) ranged from 30 to 90 minutes in all studies. CBE groups had a mean of 62.72 (16.18) minutes per session, and for control groups the mean was 65.45 (22.52) minutes per session.

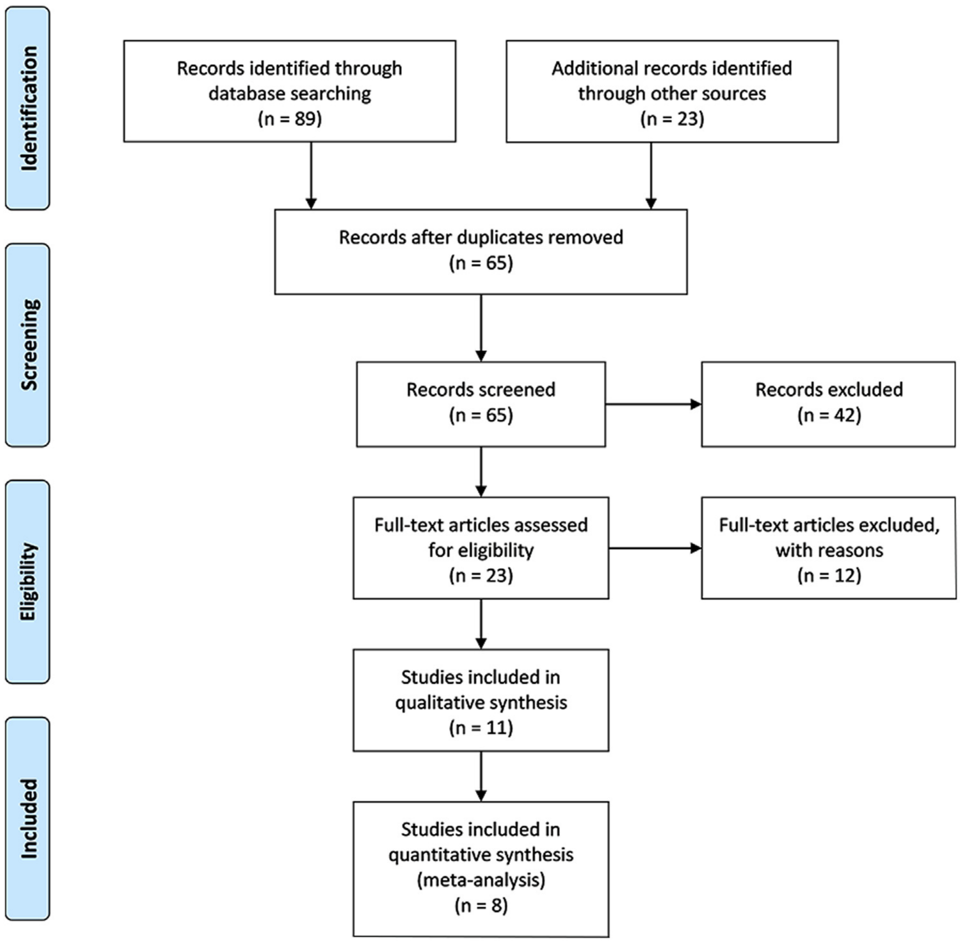

Figure 1. Flow diagram of search process to include articles.

Outcomes Characteristics

Seven studies used the 6-Minute Walk Test [8,17-21,25], and 2 used the 6-Minute Walk Test and the 5-Meter Walk Test simultaneously [17,18]. One study used the 2-Minute Walk Test [22] and 1 the 10-Meter Walk Test [8].

One article analyzed gait speed and others parameters of mobility (cadence, symmetry of posture and posture while walking, and biomechanical analysis of gait with GAITRite [CIR Systems Inc, Sparks, NJ]) [23]. In 3 studies, authors performed the Comfortable Walking Speed test, in meters per second [16,17,26].

Balance was mostly assessed with Berg Balance Scale (BBS) by 3 studies [15,17,19], 2 study used the Timed Balance Test [16], and 5 used the Timed Up-and-Go Test (TUGT) for functional balance assessment [15,17,20,21,25].

Other outcomes were assessed by only one study. The outcomes for upper limb function such as manual dexterity and grip strength were measured with various tests and scales such as Jebsen Taylor Hand Function Test, Test d'Evaluation des Membres superieurs des Personnes Agées, Purdue Pegboard, The Box and Block Test, The Nine-Hole Peg Test, the upper extremity subscale of Stroke Rehabilitation Assessment of Movement, the upper extremity subscale of Motor Assessment Scale, and isometric manual dynamometry [8,16,20,25].

Other less-common outcomes used were perceived exertion, oxygen consumption, depression, quality of life, self-satisfaction (self-esteem, motivation of rehabilitation, relationship changes), activity and participation, bone mineral density, posture symmetry and posture during walking, mobility variables (endurance, length of step, cadence), strength, and self-reported physical activity [19,21,23].

Types of Intervention of the Comparison Groups

Control Groups

Higgins et al (2006) [16], Salbach et al (2005) [18], and Salbach et al (2004) [17] proposed the same exercises for the control group. The participants trained the daily activities they wanted to improve, eg, manipulating cards, clothes pins, and writing exercises. For those who could not move their more affected arm enough to practice such tasks, the therapist assisted the

Table 1
Characteristics of included studies in the systematic review

Study	Sample Size	Age, Mean (DP)	Months Since Stroke Onset, Mean (DP)	Interventions	Outcomes	PEDro
Kim et al (2012) [25]	CBE = 10 CG = 10	CBE = 52.50 (11.72) CG = 53.40 (12.11)	CBE: 158 (121) CG: 93 (73) Chronic stage	CG: joint mobilization, muscle strengthening, and balance training, 5×/week for both groups for 1 h/d CBE: Step-ups, balance beam, kicking a ball, stand up and walk, obstacle course, treadmill, walk and carry, speed walk, walk backwards and stairs, 3×/wk for 1 h/ for 4 wk.	Trunk motor impairment; balance; mobility; gait speed	5
Higgins et al (2006) [21]	EG = 47 CBE = 44	EG = 73 (8) CBE = 71 (12)	CBE: 7.96 (2.76) EG: 7.23 (2.43) Chronic stage	CG: Training of daily activities (manipulating playing cards, clothes pins, writing exercises), recommended to practice at home. CBE: Step-ups, balance beam, kicking a ball, stand up and walk, obstacle course, treadmill, walk and carry, speed walk, walk backwards and stairs. Both groups 90 min/session 3×/wk for 6 wk	Gross manual dexterity; Fine manual dexterity; performance of arms; grip strength; performance in self-care; mobility; performance daily living; quality of life; depressive symptoms	8
Salbach et al (2005) [20]	CBE = 41 CG = 42	CBE = 71.0 (11.0) CG = 71.0 (11.0)	CBE: 7.93 (2.86) CG: 7.23 (2.46) Chronic stage	CG: Training of daily activities (manipulating playing cards, clothes pins, writing exercises), recommended to practice at home. 90 min/day CBE: Step-ups, balance beam, kicking a ball, stand up and walk, obstacle course, treadmill, walk and carry, speed walk, walk backwards and stairs. 60 min/day. Both groups 3×/ week for 6 wk.	Balance self-efficacy; walking capacity; walking speed; mobility; balance	7
Salbach et al (2004) [19]	CBE = 44 CG = 47	CBE = 71 (12) CG = 73 (8)	CBE: 7.96 (2.76) CG: 7.23 (2.46) Chronic stage	CG: Training of daily activities (manipulating playing cards, clothes pins, writing exercises), recommended to practice at home. 90 min/d CBE: Step-ups, balance beam, kicking a ball, stand up and walk, obstacle course, treadmill, walk and carry, speed walk, walk backwards, and stairs. 60 min/d. Both groups 3×/wk for 6 wk.	Comfortable walking speed; Maximum walking speed; mobility; Balance Exercise tolerance;	8

Pang et al (2005) [17]	CBE = 32 CG = 31	CBE = 65.8 (9.1) CG = 64.7 (8.4)	CBE: 62 (60) CG: 61 (42) Chronic stage	CG: Shoulder, elbow, wrist and hand muscle strength and ROM; dumbbell/wrist cuff weight exercises; passive or self-assisted range of motion to paralyzed joints; upper extremity weight-bearing; functional tasks and electrical stimulation. CBE: Brisk walking; sit-to-stand; alternate stepping onto low risers; walking in different directions; tandem walking; obstacle course; sudden stops and turns during walking; walking on different surfaces; standing on foam, balance disc, or wobble board; standing with one foot in front of the other; kicking ball; leg muscle strength; partial squats, toe rises. Both groups 3×/wk for 19 wk, 60 min/session	Maximal VO_2; mobility; leg muscle strength; balance; activity participation; metabolic equivalent; femoral neck BMD; respiratory exchange	8
Dean et al (2000) [20]	CBE = 06 CG = 06	CBE = 66.2 (7.7) CG = 62.3 (6.6)	CBE: 27 (25) CG: 15 (19) Chronic stage	CBE: Sitting at a table and reaching in different directions; sit-to-stand from various chair heights; stepping forward, backward, and sideways onto blocks of various heights; heel lifts in standing; standing with the base of support constrained, with feet in parallel and tandem conditions; reciprocal leg flexion and extension; treadmill; obstacles course; and walking over slopes and stairs. CG: Both a circuit component with subjects completing practice at a series of workstations (wrist extension, supination, grasp, and release of various objects). Both groups 60 min/session, 3×/wk for 4 wk.	Lower-limb function; speed; endurance; balance	5
Van de Port et al (2012) [21]	CBE = 125 CG = 117	CBE = 56 (10) CG = 58 (10)	CBE: 3.03 (1.4) CG: 3.43 (1.7) Subacute stage	CG: postural control, Physical conditioning and walking training CBE: 8 stations of FIT-Stroke program. Both groups 90 min/session, 2×/wk for 12 wk.	Risk of falls; ADL; anxiety; depression; fatigue; motricity; balance; visual ability	7

(*continued on next page*)

Table 1 (*continued*)

Study	Sample Size	Age, Mean (DP)	Months Since Stroke Onset, Mean (DP)	Interventions	Outcomes	PEDro
Song (2015a) [23]	GI = 9 GII = 10 GIII = 11	GI = 53.78 (9.97) GII = 58.70 (8.61) GIII = 55.82 (6.29)	GI: 36.67 (15.12) GII: 30.70 (14.68) GIII: 27.66 (19.35) Chronic stage	GI: Conventional physiotherapy 30 min/session; GII: Conventional physiotherapy plus individual TOCT 60 min/session; GIII: Conventional physiotherapy plus group TOCT 60 min/session. TOCT: sitting on a chair, standing up and walking, obstacle course, carrying objects, turning objects upside down, seed walking in circles. All groups performed sessions 3×/wk for 4 wk	Self-esteem; motivation; relationship change	3
Song (2015b) [24]	GI = 10 GII = 10 GIII = 10	GI = 62.76 (9.97) GII = 64.10 (8.61) GIII = 59.28 (5.23)	GI: 34.54 (12.20) GII: 30.70 (14.68) GIII: 22.48 (17.86) Chronic stage	GI: Conventional physiotherapy 30 min/session; GII: Conventional physiotherapy plus individual TOCT 60 min/session; GIII: Conventional physiotherapy plus group TOCT 60 min/session. TOCT: sitting on a chair, standing up and walking, obstacle course, carrying objects, turning objects upside down, seed walking in circles. All groups performed sessions 3×/wk for 4 wk	Symmetry in gait phases; cadence; velocity; distance	3
Mudge et al (2009) [8]	CBE = 31 CG = 27	CBE = 76 (range 39 – 89) CG = 71 (range 44 – 86)	More than 6 months earlier Chronic stage	CG: occupational therapy sessions, 4 educational sessions and 4 socials. 90 min/session, 2×/week CBE: sit to stand, self-sway, standing balance, step-ups, balance beam, standing hamstring curl, tandem walk, swiss ball squats, tandem stance, calf raise, backwards walk, lunges, side leg lift, marching in place, obstacle course. 60 min/session, 3×/wk. Both groups performed sessions for 4 wk.	No. of steps/day; walking speed; endurance; confidence mobility tasks; self-reported; physical activity	7
Blennerhassett and Dite (2004) [25]	CBE = 15 CG = 15	CBE = 56.3(10.5) CG = 53.9 (19.8)	CBE: 1.2 (0.83) GC: 1.67 (1.64) Acute stage.	CG: arm ergometer followed by reach and grasp, hand–eye coordination activities, stretching, and strengthening. CBE: warm-up and, stationary bike and treadmill, followed by sit to stand, step-ups, obstacle course walking, standing balance, stretching, and strengthening. Both groups performed 1 h of conventional physical therapy intervention plus 1 hour of specific group intervention, 5×/wk for 4 wk.	Mobility; UL Function	8

SD = standard deviation; PEDro = Physiotherapy Evidence Database; CBE = circuit-based exercise group; CG = control group; ROM = range of motion; VO_2 = oxygen consumption; BMD = bone mineral density; ADL = activities of daily living; GI = group I; GII = group II; GIII = group III; TOCT = task-oriented circuit training; UL = upper limb.

individual by guiding his/her limb while applying other modalities of therapy, such as vibration and passive range of movement to facilitate mobility and decrease spasticity. When subjects had maximized their performance, the tasks or their level of difficulty was changed according to therapist's discretion. All subjects received a home program to be executed for a minimum of 15 min/d during the period of intervention. The home program consisted mainly of similar tasks to those practiced during the intervention.

Kim et al (2012) [15] prescribed joint manipulation, muscle strengthening, and balance training, although they also provided conservative physical therapy for both groups in addition of each group-related intervention. Pang et al (2005) [19] prescribed muscle strengthening for shoulder, elbow, wrist, and hand, functional hand activities (pinch, grip, finger extension, playing cards, picking up objects of various sizes and shapes), and electrical stimulation for those with no active wrist movement. Dean et al (2000) [20] prescribed exercise class. The organization and delivery of this training was similar in every aspect to the experimental group training, except for the control class, which was designed to improve function of the affected upper limb (eg, wrist extension, supination, grasp, and release of various objects).

Van de Port et al (2012) [21] prescribed sessions to improve control of standing balance, physical conditioning, and walking training according to the Dutch physical therapy guidelines. Song et al [23,24] used conventional physical therapy without details of the exercises. Mudge et al (2009) [8] intervened with occupational therapy, education, and social sessions. Blennerhassett and Dite (2004) [25] used warm-up (arm ergometer) followed by functional tasks to improve reach and grasp, hand–eye coordination activities, stretching as required, and strengthening using traditional gymnasium equipment. Therapist-assisted exercises were incorporated for subjects with limited control of arm or hand movement.

CBE Groups

Kim et al (2012) [15], Higgins et al (2006) [16], Salbach et al (2004; 2005) [17,18], and Blennerhasset and Dite (2004) [25] used the same circuit exercises described by Dean et al (2000) [20]—10 workstations added to the circuit: (1) sitting at a table and reaching for objects placed beyond arm's length in different directions, to promote loading and activation of the affected leg muscles; (2) sit-to-stand from different chair heights to strengthen the affected leg extensor muscle and practice this task; (3) stepping forward, backwards, and sideways onto blocks of different heights to strengthen the affected leg muscles; (4) heel lift in standing position to strengthen the affected plantar flexor muscles; (5) standing with constrained base of support, parallel feet 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 position 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 two tasks; (8) walking on a treadmill; (9) walking over different surfaces and through obstacles; and (10) walking over slopes and stairs to practice walking under varying conditions. The participants spent 5 minutes at each workstation and then 10 minutes in walking relays and races.

Song et al (2015a [23]; 2015b [24]) used a circular variation of the CBE described by Dean et al (2000) [20]. Mudge et al (2009) [8] designed a circuit with 15 stations graded to each participant's ability and progressed as tolerated. The stations consisted of the following: (1) Sit-to-stand—increasing speed until complete 30, then decrease in seat height. (2) Self-sway—start near a wall for support, sway forward and backwards over the ankles, increasing the amplitude and progressing to standing away from the wall. (3) Standing balance—stand between parallel bars with the feet together trying to balance as far as possible, progressing by changing to crossed arms and turns of upper body, and finally standing on one leg. (4) Step-ups—start with low step, increasing step height. (5) Balance beam—step over the balance beam, leading with alternate feet, increasing the speed and progressing to crossovers. (6) Standing hamstring curl—increasing weight and repetitions. (7) Tandem walk—with the feet touching a line on floor, progressing to heel-toe, decreasing the speed, looking forward, and crossing arms. (8) Swiss ball squats—progress depth of squat until thighs are parallel with ground. Add hold, which can be progressed by increasing time. Progress further by adding weights to hands. (9) Tandem stance—start with the hands on the wall for balance, progress the base of support until heel-toe, go to the center of the room, add arms crossed. (10) Calf raise—start with double calf raise and increase speed, single calf raise and progress to jumps. (11) Backward walk—start close to the wall for balance, go to the center of the room and progress to shuttle runs. (12) Lunges—start holding on for support. Progress depth of lunge. Progress number on each leg. Progress to no support. (13) Side lag lifts—increase weight and repetitions. (14) Marching in place—Progress to marching with weight, marching with no hand support and to marching on a mini-trampoline. (15) Obstacle course—increase speed and varying the obstacles.

Pang et al (2005) [17] designed a circuit with 3 stations: Station 1—cardiorespiratory fitness and mobility: (1) brisk walking; (2) sit-to-stand, decreasing chair height; (3) alternate stepping onto low risers, increasing stepper height, reducing arm support or both. Duration: 10 minutes initially with increment of 5 minutes every week up to 30 minutes of continuous exercise as tolerated; Intensity: started at 40%-50% heart rate reserve

Table 2
Syntheses of the results across investigated outcomes

Outcome	Studies	Participants	Effect Estimate	*P* Value	Unity
GS	7	516	0.11 (0.02, 0.19)*	.02*	m/s
BBS	3	174	1.09 (-2.30, 4.49)†	.53	Categorical
TUGT	5	395	1.89 (-2.28, 6.06)†	.38	Seconds

GS = gait speed; BBS = Berg Balance Scale; TUGT = Time up and go test.
* Difference with statistical significance.
† Mean difference.

with increment of 10% heart rate reserve every 4 weeks up to 70%-80% heart rate reserve as tolerated. Station 2—Mobility and balance: (1) walking in different directions; (2) tandem walking; (3) walking through an obstacle course; (4) sudden stops and turns during walking; (5) walking on different surfaces (carpet, foam); (6) standing on a foam, balance disc or wobble board; (7) standing position, one foot in front of the other; (8) kicking a ball alternating the feet, reducing arm support and/ or increasing speed of movement. Station 3—Leg strength: (1) partial squats, increasing movement amplitude; (2) toe rise, progressing from bilateral to unilateral rise both sides, increasing the number of repetitions (from 2 sets of 10 to 3 sets of 15), reducing arm support or both.

Van de Port (2012) [21] performed the CBE intervention based on the FIT-Stroke program (Van de Port, 2009 [22]), which includes 4 stages: (1) warming up (5 minutes), (2) circuit class training (60 minutes), (3) evaluation and a short break (10 minutes), and (4) group game (15 minutes). The training program includes 8 different workstations intended to improve meaningful tasks related to walking competency, such as balance control, stair walking, turning, transfers, and speed walking. The 8 workstations incorporated in the circuit are (1) standing and reaching; (2) stair walking including transfer; (3) walking and picking up various objects from the ground; (4) kicking a ball; (5) stepping up and down; (6) walking course with obstacles; (7) transfers (lying to standing and sitting); and (8) speed walking. Graded progression was achieved by (1) increasing the difficulty of the task; (2) adding weights; or (3) increasing the number of repetitions. Each workstation lasted 3 minutes, followed by 3 minutes of rest and 1 minute to change to the next workstation.

Meta-Analysis Results

A total of 8 studies were included in the meta-analysis: Blennerhassett and Dite, 2004 [25]; Mudge et al, 2009 [8]; Song et al, 2015b [24]; van de Port et al, 2012 [21]; Kim et al, 2012 [15]; Dean et al, 2000 [20]; Pang et al, 2005 [19], and Salbach et al, 2004 [17]. All properly described the primary outcomes values (continuous dependent variables).

Table 2 presents all outcomes of the meta-analysis regarding the number of studies, number of participants, effect estimation, *P* values, and unity of measurement.

Gait Speed

The meta-analysis of the gait speed (Figure 2) was conducted with 7 studies (meters/second after standardization of unit of measurement). The size of the intervention effect was in favor to CBE (n = 125) when compared with other interventions (n = 117) (MD = 0.11 m/s; 95% CI 0.02-0.19; Z = 2.43; *P* =.03). In this analysis, 5 studies recruited chronic patients, 1 recruited acute patients [25], and 1 recruited subacute patients [21].

Balance

The meta-analysis of BBS (Figure 3) was conducted with 03 studies (CBE, n = 44; other intervention, n = 47). There was no statistical difference on BBS gains between groups (MD = 1.09 points; 95% CI: −2.30 to 4.49; Z = 0.63; *P* = .53). This analysis included only chronic patients.

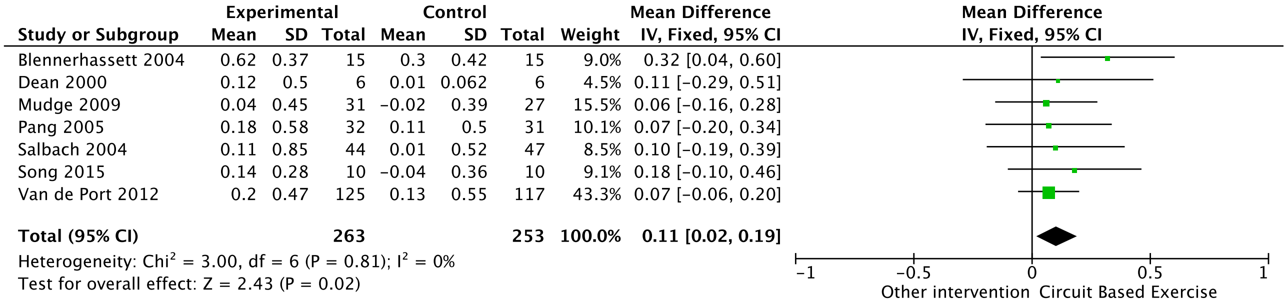

Figure 2. Meta-analysis of circuit based exercise versus conventional intervention on gait speed. Forest plot of the meta-analysis results showing the mean difference and 95% confidence interval (CI) detected for gait speed (m/s). The diamond (◆) represents the difference in mean gains between groups divided by the pooled standard deviation (SD) of different gains among groups.

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Kim 2000	6.9	6.52	10	−5.14	20.43	10	6.5%	12.04 [−1.25, 25.33]
Pang 2005	2	8.02	32	1.9	8.42	31	69.8%	0.10 [−3.96, 4.16]
Salbach 2004	2	15.56	44	1	18.38	47	23.6%	1.00 [−5.98, 7.98]
Total (95% CI)			**86**			**88**	**100.0%**	**1.09 [−2.30, 4.49]**

Heterogeneity: $Chi^2 = 2.84$, df = 2 (P = 0.24); $I^2 = 29\%$
Test for overall effect: Z = 0.63 (P = 0.53)

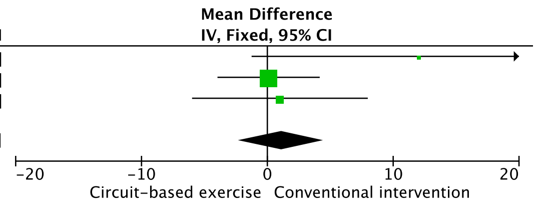

Figure 3. Meta-analysis of circuit based exercise versus conventional intervention on balance. Forest plot of the meta-analysis results showing the mean difference in weight and 95% confidence interval (CI) detected for the gait speed (m/s). The diamond (◆) represents the pooled mean difference (points; Berg Balance Scale). SD, standard deviation.

Functional Mobility

The meta-analysis of TUGT (Figure 4) was conducted with 05 studies (CBE, n = 200; other intervention, n = 195). There was no statistical difference on TUGT gains between groups (MD = 1.89 seconds; 95% CI −2.28 to 6.06; Z = 0.89; *P* = .38). In this analysis, 3 studies recruited chronic patients, 1 recruited acute patients [25], and 1 recruited subacute patients [21].

Heterogeneity and Risk of Bias

Three forest plots that reported the I^2 statistic (total [95% CI]) due the heterogeneity of the continuous data was compiled. Two analyses showed no evidence of heterogeneity ($I^2 = 0\%$): (1) CBE versus other intervention for gait speed and (2) functional mobility. One shows the presence of heterogeneity, but might not be important according to the interpretation provides by the Cochrane Collaboration [12] (1) CBE versus other intervention on balance analysis.

Risk of Bias

The risk of bias analysis demonstrated that 55% of the studies adopted an appropriate random sequence generation [8,16,17,19,20,25], and 64% had properly reported the allocation concealment [8,16-20,25]. Regarding the blinding, only 27% of the studies blinded participants and personnel [8,19,25], and 45% of the studies used blind assessment [8,16,17,19,25]. In 45% of the studies, missing outcome data had a low risk of bias [8,16,17,19,23,24]. Most of the studies reported a proper randomization and allocation concealment.

Discussion

The objective of the present systematic review was to examine the effectiveness of CBEs in the treatment of people affected by stroke. To our knowledge, the meta-analysis applied in this study was the first to identify the effects of CBE in patients with stroke after a rigorous process to confirm actual nature of this intervention, ie, an overall program to improve strength, stamina, balance, or functioning. The analysis showed that: (1) CBE is more effective than other interventions on gait speed; and (2) CBE presents similar effects when compared with others interventions on balance (BBS) and functional mobility (TUGT).

Walking speed is a traditional outcome measure used to identify motor recovery in stroke population. In this sense, there was improvement in gait speed with statistical significant increase in postintervention assessment in many clinical trials. In a recent systematic review, 10 categories of intervention used in physical therapy resulted in gait improvement, and the category related to the focus of the present review were the "multidimensional rehabilitation," which consists in strengthening and aerobic exercise, circuit class training, and circuit tilt table. Change in gait speed measured by effect sizes (SMD) ranged from 0.41 to 2.13, and all comparisons were performed between multidimensional rehabilitation versus standard training groups [25]. Regarding other systematic reviews with meta-analysis on the effectiveness of "task-oriented circuit" or "task-oriented approach" in patients with stroke, we observed a statistical significance in MD in favor of the experimental groups of 0.12 (m/s) [10] and 0.35

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Kim 2000	5.69	18	10	5.14	20.43	10	6.1%	0.55 [−16.33, 17.43]
Van de Port 2012	4	12.21	125	3	24.84	117	70.1%	1.00 [−3.98, 5.98]
Salbach 2004	1.2	27.89	44	−1.6	34.72	47	10.5%	2.80 [−10.10, 15.70]
Dean 2000	7.9	27.15	6	3	38.85	6	1.2%	4.90 [−33.02, 42.82]
Blennerhassett 2004	12.8	7.96	15	6.2	22.28	15	12.1%	6.60 [−5.37, 18.57]
Total (95% CI)			**200**			**195**	**100.0%**	**1.89 [−2.28, 6.06]**

Heterogeneity: $Chi^2 = 0.78$, df = 4 (P = 0.94); $I^2 = 0\%$
Test for overall effect: Z = 0.89 (P = 0.38)

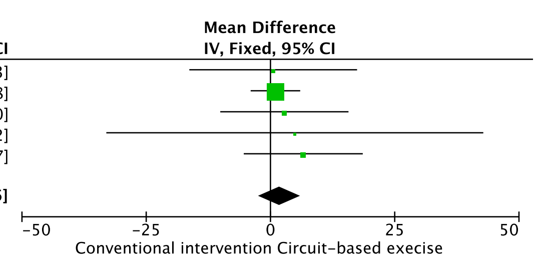

Figure 4. Meta-analysis of circuit based exercise versus conventional intervention on functional mobility. Forest plot of the meta-analysis results showing the mean difference in weight and 95% confidence interval (CI) detected for the gait speed (m/s). The diamond (◆) represents the pooled mean difference (seconds; Timed Up and Go Test). SD, standard deviation.

(m/s) [28], respectively. The present study demonstrated an MD of 0.11 in favor of CBE when compared with other interventions. Therefore, our results point out the effectiveness of CBE to improve gait speed compared with other interventions and the agreement with previous systematic reviews of task-oriented circuit.

Walking deficit for comfortable walking speed is classified as mild (>0.7 m/s), moderate (0.3-0.7 m/s), and severe (<0.3 m/s) [29]. Based on this stratification, even if the intervention effects to improve gait speed were considered small, the average gait speed of patients could reach a better category. This was clearly demonstrated by another systematic review that assessed the effectiveness of cardiovascular conditioning on comfortable gait speed. This meta-analysis showed a small increase of 0.08 m/s, but the average gait speed at the end was 0.72 m/s, which was responsible for the improvement of walking speed from moderate to mild [27]. Moreover, changes ranged from 0.10 to 0.20 m/s were demonstrated to be minimal clinically important for difference in comfortable gait speed across multiple patients with disease [30].

In contrast, stronger effects on gait speed, balance (BBS) and time of TUGT were demonstrated by Rooij et al (2016) [31], who performed a systematic review with meta-analysis to examine if the balance or gait training using virtual reality is more effective than conventional balance or gait training in stroke patients. The analysis (8 studies) demonstrated that virtual reality ($n = 108$) had a large pooled SMD (1.03; CI 0.38) when compared with conventional therapy ($n = 103$) for gait speed. A significant difference (pooled MD) for BBS (2.18 points; CI 1.52-2.85; $P < .001$) in favor of virtual reality (7 studies; $n = 180$) and for TUGT (2.48 seconds; CI 1.28-3.76; $P < .001$) in favor of virtual reality also were demonstrated compared with conventional therapy. The authors pointed out that virtual reality created patient-specific motor experiences with higher level of repetitive and variable training, and this was confirmed in 19 of the 21 studies analyzed. Since the variables were not properly described, we could not compare the results with ours.

In the present review, there were no significant effects for BBS (MD = 1.09 points; 95% CI −2.30 to 4.49; $P = .53$) and for TUGT (MD −1.89 seconds; 95% CI −2.28 to 6.06; $P = .38$) between CBE versus other interventions. The review of English and Hillier (2010) [28] showed no significant effects for TUGT (MD = −3.08 seconds; CI −7.59, 1.43; $P = .18$) and BBS (MD = 0.86 points; CI −1.02, 2.74; $P = .37$), and the study of Wevers et al (2009) [10] showed a significant effect size for TUGT (SMD = 0.26; CI 0.00-0.51; $P = .047$) but not for BBS (0.25 points; CI −0.14, 0.49; $P = .276$) when comparing task-oriented circuit versus control group (ie, ES for BBS in favor of task-oriented circuit). Regarding the BBS, this scale can produce a ceiling effect to the use in ambulant stroke survivors, and this could explain the absence of significant effects across studies [28]. This divergence between TUGT and MWT could cause an impact when analyzing postural reactive activity, which is necessary for balance maintenance and consequent bodily functions, like walking. Normal postural reactive activity is compromised in individuals with brain lesions [32], requiring longer period for gait automatism to take effect. Considering this fact, TUGT may not be appropriate to analyze these functions in individuals with brain lesions. With respect to the minimal detectable changes, 1 study reported that BBS showed absolute and relative changes of 5 points and 10%, and a TUGT of 8 seconds and 28% [33].

Limitations of this systematic review include the following: (1) We could not assess publication bias, such as the funnel plot asymmetry and Eggers' test, and according to the Cochrane Handbook for Systematic Reviews, the use of these methods with fewer than 10 studies would be imprudent [12]. (2) The large variability of the CBE characteristics of the included studies, such as time of stroke diagnosis (ranged from 1.2 to 92.4 months), duration of the studies (range from 4 to 19 weeks), frequency of sessions (2-7 times per week), and duration of sessions (30-90 minutes), which could compromise the use of the results to establish the ideal CBE dose—response. (3) Regarding the only positive and favorable outcome to CBE (gait speed outcome), one study recruited acute patients and another one included subacute patients, of the 7 used in this study. Thus, the extrapolation of the results should be done with caution, because not all studies assessed chronic patients. Considering the large disparity of the study characteristics and the small number of studies analyzed (gait speed 7 studies; BBS 3 studies; TUGT 5 studies), a future update of systematic reviews could allow more homogeneous analysis, which might help the professionals' perspective on making-decision processes.

Conclusion

Our review suggests a positive and clinically important effect of CBE on gait speed compared with other interventions. CBEs were not superior to other interventions to improve balance (BBS) and functional performance (TUGT) in a stroke population.

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Disclosure

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