CASE REPORT

Optimizing Gait Ability after Task-oriented Circuit Class Training in Posttraumatic Brain Injury: A Case Report

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Abstract

Background and purpose: Reduction in gait ability is considered the most common problems in patients with traumatic brain injury (TBI). Approximately 83% of patients with moderate to severe TBI continue to demonstrate impairments in balance and gait after discharge from rehabilitation that affect their independence in activities of daily living (ADL). This case report aimed to examine the impact of task-oriented circuit class training on gait ability focusing on balance, gait speed, and gait endurance (functional capacity) in a 34-year-old man with TBI.

Case description: The patient was a 34-year-old man with 1-year post-TBI. Twelve sessions of the task-oriented circuit class training were provided. Outcome measures included the six-minute walk test (6-MWT) and Berg Balance Scale (BBS).

Outcomes: His BBS score improved from 34/56 to 41/56. Six-minute walk distance increased by 62.9 m, and gait velocity increased by 0.25 m/second.

Conclusion: The use of the task-oriented circuit class training protocol may be feasible in patients with TBI. Through 12 sessions, the patient showed improvement in gait ability resulting from increased balance ability, gait velocity, and endurance. Future high-quality studies with a large sample size are strongly needed to verify our findings.

Keywords: Brain injuries, Case reports, Circuit-based exercise, Gait, Rehabilitation, Therapy, Traumatic.

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Introduction

Traumatic brain injury (TBI) causes disability in young people aged 29–45 years old.[1] Many subjects following TBI report many limitations in motor functions including reducing gait ability.[2] About 83% of moderate to severe TBI individuals demonstrate gait deficiencies that affect their independence in their activities of daily livings (ADLs).[3] There was a strong relationship between balance, gait speed, gait endurance, and walking ability. Poor gait ability results from a decrease in balance, gait speed, and gait endurance.[4,5]

Task-oriented circuit class training is the practice of arranging to stand- and walking-related tasks as a circuit using different terminals.[6] This training has three key features: (1) different workstations that allow patients to practice in a meaningful and progressively way to meet their needs; (2) efficient use of therapist time in which patients actively engage in task practice compared with individual therapy; and (3) group dynamics that comprise peer support and social interaction.[6,7]

A systematic review showed that task-oriented circuit class training is an effective intervention in the improvement of gait and gait-related activities in patients with chronic stroke.[6]

Recently, a systematic review showed that the task oriented is an effective intervention in improving the motor function in patients with stroke.[8]

No research has examined the impact of task-oriented circuit class training on walking ability aspects (i.e., balance, endurance, and speed) in subjects with TBI. Hence, the purpose of this CAse REport (CARE) was to investigate the effect of task-oriented circuit class training on gait ability focusing on balance, gait speed, and gait endurance in a 34-year-old man with TBI.

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Materials and Methods

Participant Information

This interventional study was performed in the Department of Physiotherapy in Alhelal center, Jordan. The patient was a 34-year-old man, who sustained a mild TBI resulting from a motor vehicle accident 1 year before this CARE. The patient height was 5.84 feet and weighed 202.83 pounds. Before his injury, he was fully independent in ADLs and had no past medical history. Additionally, he was in a good academic position and was actively involved in sports, such as soccer.

Instantly following the motor vehicle accidents, a computed tomography (CT) scan detected a right temporal mild hematoma and a temporal bone fracture. The Glasgow Coma Scale (GCS) score was 13 indicating a mild TBI.[9] The CT scan for the spine was negative. There was no evidence for bone fractures, lung, or cardiac

problems. The neurological examination at the time of injury revealed vestibular dysfunction and right spastic hemiparesis.

The patient received inpatient rehabilitation intervention after 2-week stays in an acute care setting. At discharge from inpatient rehabilitation, the participant used axillary crutches with supervision to access home and work environments.

Following discharge from inpatient rehabilitation, the participant received outpatient physiotherapy for 4 weeks. The outpatient physiotherapy was focused on increasing range of motion, improve muscle strength, enhance static and dynamic balance, and gait training. At discharge from outpatient physiotherapy, he was able to ambulate without using any assistive device. The participant's main complaints at this time were difficulty in doing some activities, such as engaging in sports, walking at a pace to keep up with his peers, and maintaining balance on irregular surfaces. A timeline according to the CARE guidelines can be seen in Flowchart 1.

Systems Review

The systems review did not reveal cardiovascular, gastrointestinal, genitourinary, or integumentary systems problems. A review of the neuromuscular system showed generalized muscle weakness on the left side of the body, abnormal posture, and gait and balance deficits. The participant demonstrated a slow walking with increased lumbar spine extension, reduced left hip, and knee joints flexion during the swing phase and absent heel strike. He demonstrated limited ability to participate in gym class secondary to reoccurring falls and difficulty in sustaining balance while participating in activities, such as football.

Clinical Impression 1

Traumatic brain injury can negatively influence aerobic endurance resulting in poor tolerance to exercise and functional activities, as well as early onset of fatigue. The effect of therapeutic interventions, such as balance and gait training in patients with TBI, has been adequately documented in the literature. However, a limited study is available on the influence of circuit training on cardiorespiratory parameters and the capability of gait.[10] The patient presented with muscle weakness on the right side, gait, and balance deficiencies that restricted his ability to sustain active participation in the activities and sports.

The participant's ability to interact efficiently, motivation to increase his functional status, and willingness to comply with the prescribed home exercise program made him a good patient for the expressed exercise program reported in this CARE. He demonstrated good static balance and trunk control; however, his inefficient gait pattern and increased effort while doing activities requiring dynamic stability along with poor endurance negatively influenced his participation.

Diagnostic Assessment

The outcome measures used in this CARE were six-minute walk test (6-MWT) and Berg Balance Scale (BBS). The outcome measures were assessed in the physiotherapy gym at baseline and then at the end of task-oriented circuit class training after 4 weeks (Table 1). The primary outcome of the 6-MWT was the distance covered by the patient in 6 minutes. It was used to assess functional capacity. The 6-MWT is a submaximal test used to assess functional capacity in individuals with chronic disorders.[11] It is well tolerated by patients.[12] The 6-MWT is a good predictor of cardiorespiratory endurance in patients with TBI.[13] The 6-MWT for a patient with TBI has shown good reliability [intraclass correlation coefficient (ICC) = 0.96–0.98] and good discriminant validity.[14,15] The test was administrated according to the guidelines provided by of American Thoracic Society (ATS).[16] Two canes were placed at 30 m from each other. Before and immediately following the test, heart rate and oxygen saturation were recorded using a pulse oximeter. The patient was able to complete the 6-MWT without taking a rest break. Gait speed was demonstrated in meters per minute by dividing the total distance covered in the 6-MWT by 6 minutes.

The balance and risk of falls were assessed using BBS. The BBS has excellent reliability (ICC = 0.986) in patients with TBI.[17] This scale includes 14 items requiring patients to achieve tasks related to the everyday life of varying levels of difficulty. A score of 0 describes an inability to achieve the task, and a score of 4 represents the ability to achieve the task independently. The total final scores range from 0 to 56. The total score of less than 45 indicates balance impairment.[18,19]

Clinical Impression 2

Baseline score of 331 m (age-based median = 557.0–774.3 m), reduced gait speed, and scored 34/56 on BBS indicated poor functional capacity and low tolerance to ADL.[20] These results were harmonious with numerous motor findings, such as reduce gait speed, decreased functional capacity, and fatigue that is seen in

Flowchart 1: Timeline of events in patient history according to CARE guidelines

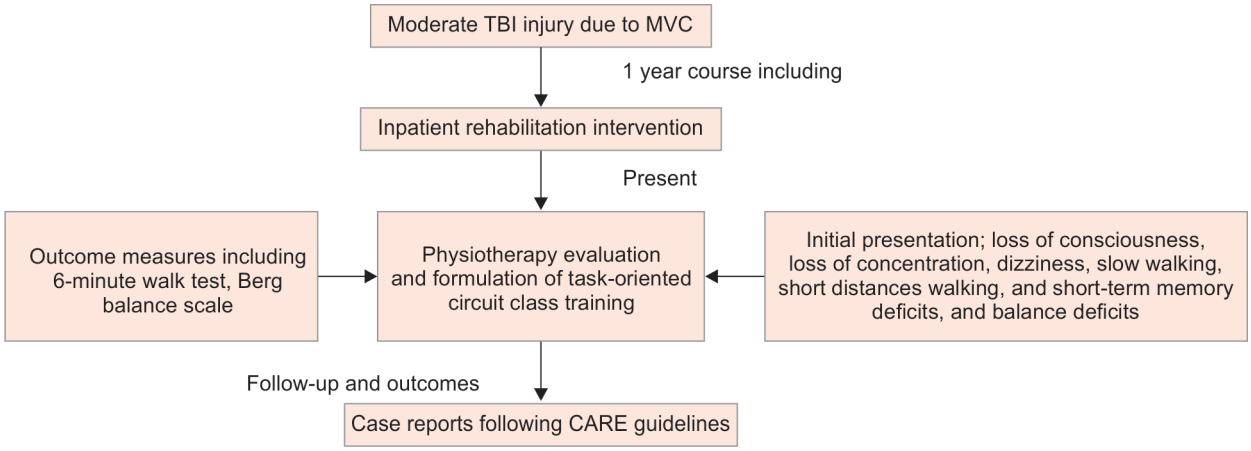

Table 1: Pre- and postintervention scores on outcome assessment

Outcome measure	*Baseline assessment*	*Postintervention assessment*	*Difference in scores*	*Reference range (mean ± standard deviation)*
Six-minute walk test (6 MWT) (distance in meters)	331	393.9	62.9	664.3 ± 49.5
Gait speed (m/second)	0.33	0.58	0.25	664.3 ± 49.5
Berg balance scale	34	41	7	*Standard error of measurement (SIM) = 1.75

*Minimal clinically important difference (MCID) and minimal detectable change (MDC) not available for participant's age group

Table 2: Steps of task-oriented circuit class training program

Serial number	*Exercise steps*
1	Gait training on a treadmill
	Walking of the treadmill with tolerated speed for 10 minutes
2	Standing up, walking to, and sitting down on a chair
	Starting position: Sitting on a chair. Rise from the chair without using hands
3	Walk along a balance beam
	Walk for 10 seconds
4	Performing step-ups
	Ten times each foot
5	Gait training — an obstacle course
	Pass through seven obstacles and back
6	Gait training while carrying an object
	Ten steps with carrying basketball
7	Walking backwards
	Ten steps
8	Up and downstairs
	Ten steps each without using hands

patients with TBI.[21] His ability to perform the activity of daily was limited secondary to reduced gait velocity, balance impairment, and low functional capacity. Patients with TBI have demonstrated an increase in energy costs while performing daily activities.[22] As the patient would participate in the community, it was essential for him to be able to walk with independently sufficient velocity, also have enough balance and endurance to be able to complete ADL with minimal or no difficulties. The investigation revealed low functional capacity as evidenced by the distance covered by the patient on 6-MWT, decreased gait velocity, and increased energy spending during ambulation. The ability of the patient to communicate adequately, his motivation to follow the physiotherapy treatment plan of care, and his goal of return to the community made him a good candidate for task-oriented circuit class training treatment intervention.

The TBI can cause impairment in a sensorimotor system that is required to maintain balance.[23] There was a significant correlation between lower extremity function and walking capacity using 6-MWT in patients with cerebral palsy.[24] Thus, it was hypothesized that a rehabilitation intervention, such as task-oriented circuit class training focusing functional training that increases balance and lower extremity function, would be supportive in improving gait capacity, gait speed, and reducing energy expenditure during walking.

Therapeutic Intervention

The task-oriented circuit class training consisted of numerous exercises to improve lower extremity function, gait, and balance. The patient was provided with a detailed description of the exercises and the number of repetitions for each exercise. The patient participated task-oriented circuit class training program inspired by Dean et al.[25] The patient performed the following exercises: Gait training on a treadmill, standing up, walking to, and sitting down on a chair, walk along a balance beam, performing step-ups, gait training an obstacle course, gait training while carrying an object, walking backward, and up and downstairs (Table 2).

Before beginning the task-oriented circuit class training, the therapist demonstrated the exercises to the participant and had the patient practice to ensure correct performance. A stopwatch was used to monitor the intervention time. The intervention started with a warm-up (5-minute) that included stretches of lower extremities muscles, followed by 30 minutes of task-oriented circuit class training. Different circuit training frequencies have been described in the literature for some populations, such as patients with TBI and diabetes mellitus. Performing circuit training 2 to 3 days/week for 8–12 weeks showed improvements in muscle strength, power output, and cardiorespiratory endurance.[10,26,27] Based on these findings, the task-oriented circuit class training intervention period was designed for 3 days/week for 4 weeks.

Ten exercises were selected for the task-oriented circuit class training program, and the patient performed each exercise at 10 repetitions for 30 minutes. Short breaks (~1–5 minutes) were allowed, depending on patient tolerance. The patient was instructed to repeat the exercises in the same order and continue to perform the exercises for 30 minutes. Exercises were progressed by increasing the exercise volume by performing multiple circuits. This method of progression was chosen so that the patient could maintain consistency in performance and safely perform the exercises at the gym. The patient kept a record of how many times and how quickly he was able to complete the 10 exercises.

The therapist followed up every week with the patient to ensure regular and appropriate performance of exercises. The therapist provided visual and verbal feedback, as well as needed to make sure the appropriate performance of the training. The amount of feedback was decreased with time. Additional details on the task-oriented circuit class training program including specific exercises can be found in Table 2. Weekly exercise logs were used to monitor consistent adherence to the frequency and duration of the task-oriented circuit class training.

Follow-up and Outcomes

The outcome measures were assessed at baseline and after 4 weeks of intervention. At the end of 4 weeks, the patient completed the task-oriented exercise circuit four times in 30 minutes as compared to two times at the beginning of the task-oriented circuit class training indicating improved endurance levels. The patient improved in gait velocity by 0.25 m/second (0.33–0.58) along with an improvement in the distance on the 6-MWT by 62.9 m (331–393.9 m) after the intervention. Moreover, the patient improved in balance by seven points on the BBS (34–41) postintervention. This improvement was also evidenced by the patient's subjective report that he was able to walk faster and had improvements in his balance while walking especially on an uneven surface, such as grass. Details of the baseline and postintervention outcome measurements are reported in Table 1.

Discussion

This CARE described the influence of a 4-week task-oriented circuit class training program on gait ability in a 34-year-old man with moderate TBI. The preliminary outcomes of this CARE suggest that 12 sessions improve gait capacity, gait velocity, and balance in a patient with moderate TBI. The duration and frequency of circuit training have been stated to range from 4 to 12 weeks.[10,28] Shorter duration of circuit training showed improvement in gait velocity, muscle strength, and sit to stand performance in children with cerebral palsy.[28] Bhambhani et al. described that maximum benefits were showed in the first 6 weeks of circuit training in a 12-week circuit training intervention. Based on these findings, the duration of task-oriented circuit class training was designed as 4 weeks.[10]

The 6-MWT revealed an improvement in the distance covered by 62.9 m (331–393.9 m) after the intervention. Despite the improvement in gait endurance and velocity using 6-MWT, the distance remained lower than the average age-based median normative value of 660.9 (557.0–774.3) meters.[20] The patient improved in gait velocity by 0.25 m/second by the end of the 4-week task-oriented circuit class training intervention. This improvement in gait velocity exceeded the minimal detectable change (MDC) of 0.21 m/second reported in patients with TBI[29] indicating a meaningful change in gait velocity following the circuit training intervention. A significant increase in gait velocity exceeding the minimal clinically important difference (MCID) of 0.2 m/second with circuit training has also been previously shown in patients with stroke.[7] The improvement in gait velocity observed in this patient with moderate TBI highlights the importance of circuit training in patients with TBI. Wevers et al. reported that task-oriented circuit class training is an effective intervention in improving gait and gait-related activities in patients with chronic stroke.[6] Moreover, Salbach et al. have shown that intensive, task-oriented training can induce greater improvement in walking ability in patients with stroke than usual practice.[30] The patient improved in balance from 34/56 to 41/56 on BBS by the end of the 4-week task-oriented circuit class training program. The baseline measurement on BBS 34/56 indicates a moderate risk of falls, while the score of 41/56 indicates a low risk of falling.[18] Kim et al. showed that task-oriented circuit class training practice would improve the balance in subacute stroke patients.[31] At the end of the 4-week task-oriented circuit class training, the patient's subjective report that he was able to walk faster and had improvements in his balance ability while walking on an uneven surface, such as grass.

The task-oriented circuit class training program showed a significant improvement in the forebrain region means compared to other areas of the brain. The forebrain region was activated more to execute motor functions.[32] Moreover, the task-oriented circuit class training increases the excitability of the motor area within the cerebrum, which can stimulate the recovery of motor control.[33] The task-oriented training as a repetitive functional meaningful physical performance for a specific functional task. It used to improve physical impairments and maximize functional performance abilities.[8]

There were some limitations to this CARE. The VO_2 max may provide an accurate examination of energy expenditure in perfect sittings; however, in physiotherapy gym sittings, the use of VO_2 max may not be a feasible choice and other measures, such as 6-MWT with a portable metabolic system, may include in future studies.[34] Future studies are recommended on assessing the impact of task-oriented circuit class training on gait velocity, balance, and walking capacity in patients with moderate TBI.

Conclusion

The task-oriented circuit class training intervention may improve gait ability in patients with TBI following a 4-week intervention protocol. Using 30-minute task-oriented circuit class training may improve balance, walking speed, and functional capacity in the TBI population. Future high-quality clinical trials with large sample size strongly needed to verify our findings.

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