CAHIERS MAGELLANES-NS
Volume 06 Issue 2
2024

ISSN:1624-1940
DOI 10.6084/m9.figshare.2632574
http://magellanes.com/

COMPARISON OF TASK-ORIENTED MOTOR SEQUENCE LEARNING EXERCISES VERSUS IMPAIRMENT-ORIENTED MULTICOMPONENT EXERCISES ON GAIT PARAMETERS AND EFFICIENCY IN CHRONIC STROKE PATIENTS

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ABSTRACT

Background. Definitive evidence that exercise interventions that improve gait also reduce disability is lacking. A task-oriented, motor sequence learning exercise intervention has been shown to reduce the energy cost of walking and improve gait speed, but whether the intervention also improves activity and participation has not been demonstrated in chronic stroke.

Objective: To investigate whether the task-oriented, motor sequence learning exercises act betterthan impairment-oriented multi-component exercises on gait parameters and efficiency in chronic stroke patients.

Methodology: This study was a single-blind, experimental study.Setting. The study was conducted at'Jain Neuro& IVF Hospital.The study participants were 45 older adults (mean age 55.93 years, SD4.85) with variable gait in chronic stroke. The intervention was a 3-week, physical therapist–guided program of Task oriented or Impact oriented. Measurements. confidence in walking determined with the Gait Efficacy.10-meter walk test evaluates gait velocity in chronic stroke patients using the Emory Functional Ambulation Profile (E-FAP).The items represent a range of challenges from level walking to walking on uneven surfaces, curbs, or stairs.

.Conclusions. Task-oriented motor sequence learning exercises are effective in improving stride length, step length, cadence, and gait efficiency scale in chronic stroke patients. The task-oriented motor sequence learning exercises offered advantages over the impairment-oriented multicomponent exercises in terms of rate of learning and the ability to maintain the skill level achieved during training.

KEYWORDS: STROKE, GAIT, **TASK**-ORIENTED MOTOR SEQUENCE LEARNING EXERCISES,

CAHIERS MAGELLANES-NS
Volume 06 Issue 2
2024
ISSN:1624-1940
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http://magellanes.com/

INTRODUCTION

Stroke is the leading cause of disability in the elderly and a significant source of disability in younger adults.[1] The middle Cerebral artery (MCA) is the second of the two main branches of the internal carotid artery and supplies the entire lateral aspect of the cerebral hemisphere.Impaired walking resulting from hemiparesis following stroke, greatly contributes to functional disability.[2]The ability to walk is the prime factor that determines if a patient is fit to be discharged home if he needs continued rehabilitation in a nursing home setting or if he or she will return to the previous level of productivity after stroke.[3]After a stroke, 50-80% of survivors will be walking independently of which 64% who are initially dependent on walking, regain their independence.[5] The recovery of walking function occurs usually in the first 6 months after stroke[5], however, the degree of recovery in walking function is uncertain.[3]

The walking patterns of normal individuals under standardized conditions are extremely consistent.[6] The walking patterns of the hemiplegic patients on the other hand are quite bizarre depending upon the site and severity of the lesion and the manner of compensation employed by the patient.[7] Several studies[8-12] have demonstrated the asymmetrical nature of the hemiplegic gait. It has been found that hemiplegic gait is slower, and laborious, with shorter stride length, low cadence, increased double support phase, and asymmetrical single limb support phase. Patients with stroke support most of their body weight by using their involved lower extremities, showing distinct asymmetry in stance and weight bearing.[13]An adult hemiplegic patient with pusher's syndrome illustrated an inability to integrate visual-vestibular and somatosensory input for midline orientation unequal firing from the opposite side of the vestibular system, as in unilateral vestibular hypofunction produces a mismatch that is subsequently interpreted as head rotation when there is no actual head movement.Attention, cognition, and memory often impaired in hemiplegic and head-inured clients, are critical for optimal balance function. Attentional deficits reduce awareness of environmental hazards and opportunities interfering with anticipatory postural control.[11] certain aspects of balance control change with age, resulting in a slight postural instability.[10]The changes in the somatosensory, vestibular, and visual systems have indicated significant deterioration in this system in older adults.[24]

Falls occur frequently during walking in people with strokeand are influenced by the surrounding environment, as well as by impairments and restrictions in the activities and participation domain. Improvement of body functions such as muscle strength and balance can reduce falls. Exercise program training includes such aspects as endurance, muscle strength, mobility, flexibility, and sensory training separately or in combination or has concentrated on only one component of the postural control system. The impact of exercises was superior in improving gait and efficiency. These exercises (either task-oriented, motor sequence learning exercises or impairment-oriented, multicomponent exercises) demonstrated great improvement in gait speed. This study will focus on the gait parameters of patients suffering from chronic stroke.

METHODOLOGY

Study Design

This was a Single blinded pre-post experimental design study in which clinical assessment was performed at two-time points. Sampling – convenient sampling was used. Each Participant received a

ISSN:1624-1940
DOI 10.6084/m9.figshare.2632574
http://magellanes.com/

single session for 45 minutes with a 15-minute warm-up session for 3 weeks. The sequence ofintervention was randomly allocated by drawing lots. All the participants were informed about the study, and written informed consent was obtained from everyone.

Selection of Study Participants

Participants were selected for the study based on the following inclusion criteria: (i) Middle cerebral artery Chronic stroke patients diagnosed by a neurologist and verified by CT/MRI in the age group of 45-65; (ii) Ability to walk in 10m without assistance; (iii) post-stroke 12 months; (iv) Mini-mental state of examination (MMSE) score more than 24. Participants were excluded if they had(i) any other neurological condition other than stroke; (ii) any hearing, visual, or vestibular impairment; (iii) lower extremity amputation; (iv)Global Aphasia; (v) Concurrent participation in another clinical trial. All participants were recruited from the Jain Neuro & IVF Hospital Pvt New Delhi. At baseline, the participant's gender, age, duration of stroke, and details about medications were recorded.

Apparatus Required:Record book, Stopwatch, Marker, Measuring tape, Paper, Ink, weight cuffs, A chair 46 cm, and a Ball used for conducting this study.

Procedure

These subjects wererandomly selected in two groups.Group 1 consisted of 15 middle cerebral artery chronic stroke patients who were trained under task-oriented, motor sequence learning exercise (TO). During this session, attention was focused on timing andcoordination to make walking easier. Group 2 consisted of 15 chronic stroke patients who were trained under impairment-orientedmulti-component exercise (IO). During this session, attention was focused on strength, balance endurance, and correct gait to increase the capacity to walk.

In task-oriented, subjects were instructed to perform, stepping forward across the midline of the body in one direction and in another direction,alternate side of stepping and alternate forward and backward stepping, and oval and spiral walking in combination with upper-extremity tasks such as carrying,rolling,bouncing or tossing a ball. In impairment-oriented, subjects were instructed to begin with a brief warm-up of gentle stretching for the leg and trunk muscles then instructed to perform balance exercises started with feet positioned at the participant's self-selected speed,stair climbing-like activity.All patients participated in 60-minute balance training sessions five times a week for three weeks.The duration and the frequency of this training were chosen because previous studies have shown that a 10-15-hour balance training program was effective in improving balance performance.20 repetitions in each session for 45 minutes after 15 minutes warm-up.First 10 repetitions were performed with balance training and then 10 repetitions were practised with progression exercises.Mini-mental scale was used to determine any cognition condition that would affect the ability of participants to follow instructions. Before and after 15 training sessions each participant was instructed to walk at their preferred pace 6 meters.

Subjects ambulated 9.2 meters (30 feet) on a paper walkway with ink patches on their foot,which left behind a footprint record. Ambulation time for 6.1m (20 feet) was recorded with a stopwatch. The first and last 1.5 meters (5ft) of the walk were not used. We obtained footprints on the paper walkway to

ISSN:1624-1940
DOI 10.6084/m9.figshare.2632574
http://magellanes.com/

measure stride length and step length. The stride length is the distance between the heel strike of one foot to heel strike of the same foot. The step length is the distance from the heel strike of one foot to the next heel strike of the opposite foot.

Measures

The mini mental scale evaluates general cognitive ability,including orientation to date, registration (immediate recall), attention and calculation, recall of 3 words and language with a score of 24 suggesting decreased cognitive ability (eg. Dementia). The MMSE has been shown to have a good test-retest reliability with the same (r=.887) or different (r=.827) examiners.[100]10 meter walk test evaluates gait velocity in chronic stroke patients with high inter rater reliability results (ICC5.997) using Emory Functional Ambulation Profile (E-FAP).[109] 10 meter walk test measures gait velocity over a short distance in the clinic in people who are undergoing inpatient rehabilitation after stroke.Gait efficacy scale is a self-report 10-items scale of perceived confidence in walking ability. Participants items in the GES are rated from 1 (no confidence) to 10 (complete confidence). The items represent a range of challenges from level walking to walking on uneven surfaces, curbs or stairs. The GES total score is the sum of the scores for the items, with a range of 10 to 100.

Statistical Analysis Continuous data were summarized as Mean ± SD while discrete (categorical) in no and %. Groups were compared by independent Student's t test. Groups were also compared by repeated measures analysis of variance (ANOVA) using general linear models (GLM) and the significance of mean difference within and between the groups was done by Tukey post hoc test after ascertaining normality by Shapiro-Wilk test and homogeneity of variances by Levene's test. Categorical groups were compared by chi-square (χ^2) test. A two-tailed (α=2) p-value less than 0.05 ($p<0.05$) was considered statistically significant.

RESULTS

The present study compares the effect of task-oriented motor sequence learning exercises and impairment-oriented multicomponent exercises on GAIT parameters and efficiency in chronic patients. A total of 30 convenient middle cerebral artery chronic stroke patients of either sex were recruited and evaluated. Subjects were randomized equally in two groups to be treated either with impairment-oriented multicomponent exercises (Group A) or task-oriented motor sequence learning exercises (Group B). The basic characteristics (age and sex) of the two groups at admission aresummarized in Table 8.1 and also shown graphically in Graphs 8.1 and 8.2, respectively.

The age of Group A and Group B ranged from 48-64 yrs and 48-65 yrs, respectively with mean (± SD) 55.93 ± 4.85 yrs and 55.80 ± 5.67 yrs, respectively. Comparing the mean age of two groups, t test revealed similar age between the two groups (55.93 ± 4.85 vs. 55.80 ± 5.67, t=0.07; p=0.945) (Table 8.1 and Graph 8.1). Further, in both groups, there were 10 males (66.7%) and 5 females (33.3%). The sex distribution (M/F) was also similar between the two groups (M/F: 10/5 vs. 10/5, χ^2=0.00, p=1.000) (Table 8.1 and Graph 8. 2).

The comparisons concluded that the subjects of the two groups were demographically matched and thus comparable and these may also not influence the study outcome measures (stride length, step length,

ISSN:1624-1940
DOI 10.6084/m9.figshare.2632574
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cadence, and gait efficiency scale score).

Table 8. 1: Basic characteristics (Mean ± SD) of two groups

Characteristics	Group A (n=15) (%)	Group B (n=15) (%)	p-value
Age (yrs)	55.93 ± 4.85	55.80 ± 5.67	0.945
Sex:			
Males	10 (66.7%)	10 (66.7%)	1.000
Females	5 (33.3%)	5 (33.3%)	

Stride length

The effect of impairment-oriented multi-component exercises (Group A) and task-oriented motor sequence learning exercises (Group B) on stride length is summarized in Table 8.2 and also depicted graphically in Graph 8.3. Table 8.2 and Graph 8.4 showed that the mean stride length in both groups increased (improved) after the exercise (i.e. Pre to Post) and the increase (improvement) was higher in Group B than in Group A.

Comparing the effects of both groups and periods on stride length, ANOVA revealed a significant effect of both groups (F=7.10, p=0.013) and periods (F=286.07, p<0.001) on stride length. Further, the interaction (groups x periods) effect of both on stride length was also found significant (F=58.82, p<0.001).

Further, for each group, comparing the mean stride length within the groups (between periods) (Table 8.2 and Graph 8.3), Tukey test revealed a significant (p<0.001) increase (improvement) in stride length of both groups at post as compared to pre. Similarly, for each period, comparing the mean stride length between the groups (Table 8.2 and Graph 8.4), Tukey test revealed similar (p>0.05) stride length between the two groups at pre, indicating stride length comparable. However, at post, the mean stride length of Group B was significantly (p<0.001) higher as compared to Group A, indicating higher improvement in Group B than Group A. Further, comparing the net mean improvement (i.e. mean change from pre to post) in stride length of two groups, t-test revealed significantly higher (62.4%) improvement in Group B as compared to Group A (2.22 ± 1.03 vs. 5.89 ± 1.54, t=7.67, p<0.001)

Table 8.2: Pre and post stride length (Mean ± SD, n=15) of two groups

Groups	Pre	Post	p-value
Group A	89.67 ± 1.38	91.88 ± 1.58	<0.001
Group B	89.30 ± 1.85	95.19 ± 1.75	<0.001
p value	0.928	<0.001	-

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DOI 10.6084/m9.figshare.2632574
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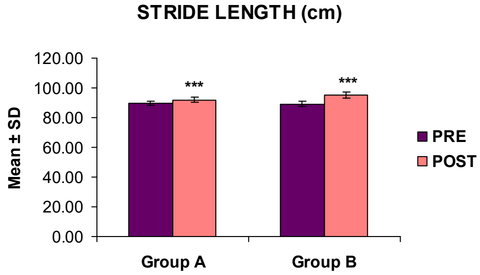

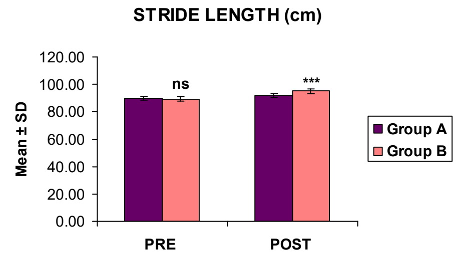

Graph 8.3.***p<0.001- as compared to Pre Graph 8.4.nsp>0.05 or ***p<0.001- as compared to Group A

Step length

The effect of impairment-oriented multi-component exercises (Group A) and task-oriented motor sequence learning exercises (Group B) on step length is summarized in Table 8.3. Table 8.3 showed that the mean step length in both groups increased (improved) after the exercise (i.e. Pre to Post) and the increase (improvement) was evidently higher in Group B than in Group A.

Comparing the effects of both groups and periods on step length, ANOVA revealed a significant effect of both groups ($F=15.56$, $p<0.001$) and periods ($F=521.27$, $p<0.001$) on step length. Further, the interaction (groups x periods) effect of both on step length was also found significant ($F=144.07$, $p<0.001$).

Further, for each group, comparing the mean step length within the groups (between periods) (Table 8.3 and Graph 8.5), the Tukey test revealed a significant ($p<0.001$) increase (improvement) in step length of both groups at post as compared to pre.

Similarly, for each period, comparing the mean step length between the groups (Table 8.3 and Graph 8.6), the Tukey test revealed similar ($p>0.05$) step length between the two groups at pre, indicating it is comparable. However, at most, the mean step length of Group B was significantly ($p<0.001$)higher as compared to Group A, indicating higher improvement in Group B than Group A.

Further, comparing the net mean improvement (i.e. mean change from pre to post) in step length of two groups, the t-test also revealed significantly higher (68.9%) improvement in Group B as compared to Group A (1.26 ± 0.81 vs. 4.05 ± 0.39, $t=12.00$, $p<0.001$).

Table 8. 3: Pre and post-step length (Mean ± SD, n=15) of two groups

Groups	**Pre**	**Post**	**p-value**
Group A	42.29 ± 0.57	43.55 ± 0.90	<0.001
Group B	42.09 ± 0.91	46.14 ± 1.09	<0.001
p-value	0.927	<0.001	-

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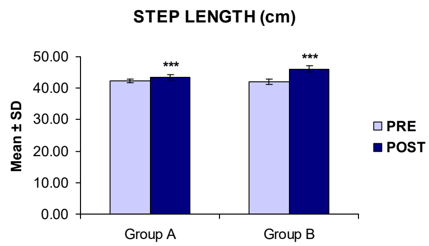
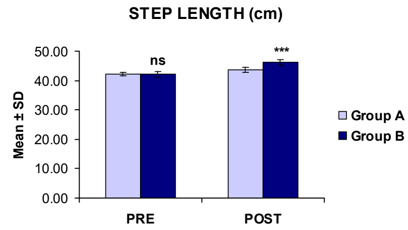
http://magellanes.com/





$^{***}p<0.001$- as compared to Pre$^{ns}p>0.05$ or $^{***}p<0.001$- as compared to Group A

Cadence

The effect of impairment-oriented multi-component exercises (Group A) and task-oriented motor sequence learning exercises (Group B) on cadence is summarized in Table 8.4. Table 8.4 showed that the mean cadence in both groups increased (improved) after the exercise (i.e. Pre to Post) and the increase (improvement) was evident higher in Group B than in Group A.

Comparing the effects of both groups and periods on cadence, ANOVA revealed a significant effect of both groups (F=4.81, p=0.037) and periods (F=752.48, p<0.001) on cadence. Further, the interaction (groups x periods) effect of both on cadence was also found significant (F=179.74, p<0.001).

Further, for each group, comparing the mean cadence within the groups (between periods) (Table 8.4 and Graph 8.7), the Tukey test revealed a significant (p<0.001) increase (improvement) in cadence of both groups at post as compared to pre.

Similarly, for each period, comparing the mean cadence between the groups (Table 8.4 and Graph 8.8), the Tukey test revealed a similar (p>0.05) cadence between the two groups at pre, indicating it was comparable. However, at post, the mean cadence of Group B was significantly (p<0.01) higher as compared to Group A, indicating higher improvement in Group B than Group A.

Further, comparing the net mean improvement (i.e. mean change from pre to post) in the cadence of two groups, the t-test also revealed significantly higher (65.7%) improvement in Group B as compared to Group A (4.88 ± 2.06 vs. 14.21 ± 1.74, t=13.41, p<0.001)

Table 8.4: Pre and post-cadence (Mean ± SD, n=15) of two groups

Groups	Pre	Post	p-value
Group A	65.19 ± 6.70	70.07 ± 6.69	<0.001
Group B	65.85 ± 6.85	80.06 ± 6.65	<0.001
p-value	0.993	0.002	-

ISSN:1624-1940
DOI 10.6084/m9.figshare.2632574
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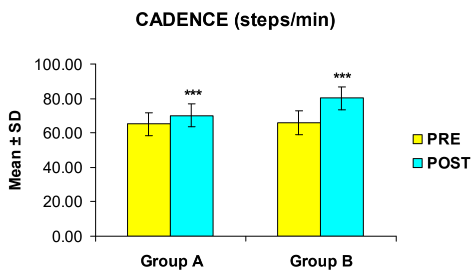

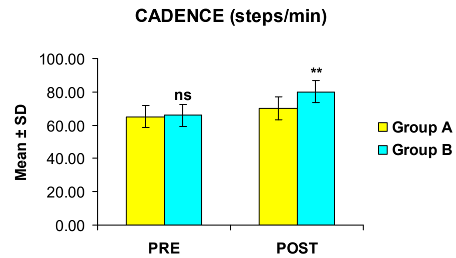

***p<0.001- as compared to Pre ns p>0.05 or **p<0.01- as compared to Group A

Gait efficiency

The effect of impairment-oriented multi-component exercises (Group A) and task-oriented motor sequence learning exercises (Group B) on gait efficiency scale score is summarized in Table 8.5. Table 8.5 showed that the mean gait efficiency scale score in both groups increased (improved) after the exercise (i.e. Pre to Post) and the increase (improvement) was evident higher in Group B than in GroupA.

Comparing the effects of both groups and periods on the gait efficiency scale score, ANOVA revealed the insignificant effect of groups (F=2.13, p=0.155) while the significant effect of periods (F=3802.56, p<0.001) on the gait efficiency scale score. However, the interaction (groups x periods) effect of both on the gait efficiency scale score was found significant (F=934.27, p<0.001). Further, for each group, comparing the mean gait efficiency scale score within the groups (between periods) (Table 8.5 and Graph 8.9), the Tukey test revealed a significant (p<0.001) increase (improvement) in the gait efficiency scale score of both groups at post as compared to pre. Similarly, for each period, comparing the mean gait efficiency scale score between the groups (Table 8.5 and Graph 8.10), the Tukey test revealed a similar (p>0.05) gait efficiency scale score between the two groups at pre, indicating it is comparable. However, at post, the mean gait efficiency scale score of Group B was significantly (p<0.05) higher as compared to Group A, indicating higher improvement in Group B than Group A.

Further, comparing the net mean improvement (i.e. mean change from pre to post) in the gait efficiency scale score of the two groups, the t-test also revealed significantly higher (66.3%) improvement in Group B as compared to Group A (3.91 ± 0.76 vs. 11.59 ± 0.61, t=30.57, p<0.001).

Table 8.5: Pre and post-gait efficiency scale score (Mean ± SD, n=15) of two groups

Groups	Pre	Post	p-value
Group A	66.24 ± 7.29	70.15 ± 7.42	<0.001
Group B	66.41 ± 7.59	78.00 ± 7.81	<0.001
p value	1.000	0.038	-

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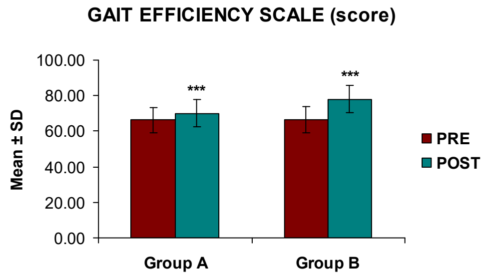
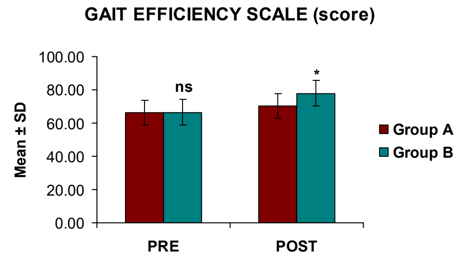
ISSN:1624-1940
DOI 10.6084/m9.figshare.2632574
http://magellanes.com/





***p<0.001- as compared to Pre^{ns}p>0.05 or *p<0.05- as compared to Group A

DISCUSSION

This study found that it was feasible to implement task-oriented motor sequence learning exercises on gait parameters and efficiency in middle cerebral artery chronic stroke patients. This result provides the framework for strategies used to train balance in our case report. Task-oriented motor sequence learning exercises have been used to emphasize timing and coordination to make walking easier and impairment-oriented, multicomponent exercises emphasizestrength, balance, endurance, and correct gait abnormalities to increase the capacity to walk. We found that participants in both groups could learn to coordinate the two.

However after training, gait speed improved with both forms of exercise, the improvement was marginally greater in the TO group than in the IO group. The TO program led to greater gains in some activity and participation outcomes than the IO program. These greater gains appeared to be partially mediated by the improvement in gait efficiency.

After the TO program, activity improved in terms of daily physical function, especially, basic activities of daily living involving the lower extremities, and total physical function and participation improved marginally. The impact of the motor sequence learning exercises on basic lower-extremity functioning, with a marginal impact on total physical function and disability, may be secondary to the focus of the intervention on “fixing” gait. The motor sequence learning interventions were targeted at correcting deficits in the muscle patterns of stepping and integrating posture with the phases of gait through task-oriented, progressive stepping, and walking tasks.

The motor sequence learning exercise also differed from the impairment-based exercise in that the stepping and walking patterns in the TO program were designed to facilitate the implicit motor learning of movement patterns. The exercise activities in the TO program were all task-oriented but there was no mention of which muscles to contract or where to place steps or shift body weight. The impairment-oriented exercise facilitated improvements in body systems that contribute to the ability to walk. However, the IO program was not task-oriented and was not designed to facilitate the implicit learning of how to integrate increased physiological capacities with walking.

Data supports our experimental hypothesis i.e. task-oriented motor sequence learning exercises are more effective than impairment-oriented multicomponent exercises on gait parameters and efficiency in chronic stroke patients. Results show improvement in both groups after 3 weeks of training sessionsi.e. improvement under both types of exercises i.e.impairment-oriented multicomponent exercises and task-oriented motor sequence learning exercises on comparison between group A and

ISSN:1624-1940
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group B. task-oriented motor sequence learning exercises showed more improvement than group A with impairment-oriented multicomponent exercises.
Our study shows that task-oriented motor sequence learning exercises improve stride length, step length, cadence, and gait efficiency scale in middle cerebral artery chronic stroke patients as compared to impairment-oriented multicomponent exercises. There is evidence in the literature that has been proved that individuals with Parkinson's disease improved the temporal motor parameters studied during walking when receiving external auditory cues. And suggest that auditory-paced stimulation is likely to be a novel and inexpensive tool for improving gait parameters and for gait rehabilitation. Therefore auditory tone discrimination makes an important component of our study protocol.
Previous studies support the benefits of these exercises on balance and coordination. Researchers found that participants in these exercise programs with either task-oriented motor sequence learning exercisesorimpairment-oriented multicomponent exercises could learn to improve functional outcomes and mobility-related activities.Van Peppen et al studied the similar impact of task-oriented but not much impairment targeted physical therapy exercise interventions on functional outcomes after stroke. Although impairment-targeted exercise interventions improved range of motion, strength, and exercise tolerance, only task-oriented exercise interventions improved function in task-representing activities of daily living.
Task-oriented, gait-related exercises were effective and efficient in improving functional outcomes after stroke in a summary of several systematic reviews of interventions to improve mobility-related activities.

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