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Effects of Group Task-Oriented Circuit Training on Motor Function, ADLs and Quality of Life in Individuals with Chronic Stroke: A Case Study

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과제지향적순환훈련이 만성 뇌졸중 환자의 운동기능, 일상생활동작 및 삶의 질에 미치는 영향 : 사례연구

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Abstract The purpose of this study was to examine the effects of group task-oriented circuit training (TOCT) based on motor learning applied in conjunction with physical and occupational therapy on functional activity, activities of daily living (ADLs), and quality of life in individuals with chronic stroke. Six chronic stroke patients participated for a duration of 31 weeks. Treatment outcomes were assessed via Chedoke-McMaster Stroke Assessment, the Berg Balance Scale, the Assessment of Motor and Process Skill (AMPS), and the Stroke Impact Scale pre- and post-intervention. The participants exhibited significant improvements in impairment, static and dynamic balance, and mood and emotion after group TOCT. The results of AMPS indicated an improvement in the motor area in 3 of the subjects. In the process area, 4 of the subjects exhibited improvement. The results of this study suggest that TOCT is beneficial to physical functions for chronic hemiparetic stroke patients in community-dwelling.

요 약 본 연구의 목적은 만성뇌졸중 환자에게 운동학습이론을 기초한 물리치료와 작업치료를 병행한 집단 과제지향적 순환훈련 프로그램을 실시하여 운동기능, 일상생활동작과 삶의 질적인 변화를 알아보고자 하였다. 6명의 만성 뇌졸중 환자에게 31주간 실시하였다. Chedoke-McMaster 뇌졸중평가, 균형검사, 일상생활활동 운동·처리기술 평가(Assessment of Motor and Process Skills: AMPS)와 뇌졸중 영향척도 측정을 치료 전과 후에 수집하였다. 연구결과, 운동기능 손상영역, 균형과 뇌졸중 영향척도의 기분과 정서영역에서 통계적으로 유의하게 향상되었다. 일상생활활동 운동·처리기술 평가는 운동(motor)영역에서 6명 중 3명에게 처리(process)영역은 4명에서 훈련 후 향상되었다. 본 연구결과를 바탕으로 집단 과제지향적 순환훈련은 지역사회 만성 뇌졸중 환자의 신체적 기능 향상에 이점이 있다고 제언하는 바이다.

Key Words : AMPS, Chronic Stroke, Motor Function, SIS, Task-oriented Circuit Training.

1. Introduction

Over 80% of stroke survivors lose gait function, with typical gait velocity reduced from approximately 1.33 m/s to approximately 0.38 - 0.8 m/s[1]. This slow gait is inadequate for safe passage across a crosswalk, even after discharge from the hospital. In addition, the

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reduced ability to perform physical functions may persist for six months to three years following stroke[2]. Fortunately, in the absence of a new incident, stroke patients tend to maintain the functional recovery achieved during rehabilitation over the long-term, although beyond 3-5 years, there is a slight decrease in performance due to the effects of increasing age and comorbidities[3].

After a stroke, severe disabilities develop affecting most activities of daily living (ADLs), including eating, dressing, and personal care, which largely depend on upper extremity function[4]. Functional disabilities are not limited to motor control and ADLs, but also influence patient mood and quality of life. Therefore, stroke survivors often participate in a rehabilitation program for the rest of their lives[5]. However, an initially slow recovery resulting in decreased motivation, the burden of medical costs, and urged discharge from the hospital are obstacles to continued rehabilitation[6].

Various neuro-rehabilitation approaches, such as neurodevelopment treatment (NDT), proprioceptive neuromuscular facilitation (PNF), Brunnstrom's method, and Rood's method, have been widely applied in stroke patients. However, there is a lack of evidence for the therapeutic effectiveness of these treatments, and their efficacy in improving functional activity is particularly unclear[7,8].

Task-oriented circuit training (TOCT) has been developed from learning theory. This approach emphasizes goal-oriented tasks with precise feedback patterns for acquisition and retention of a new skill[9]. TOCT involves workstations that reproduce physical activities that the subject usually performs during daily living such as walking, climbing stairs, and maintaining balance with the aim of promoting motor learning and task retention. Previous studies have shown that TOCT is a good method for improving locomotive function and mobility in survivors following stroke.

Targeting chronic stroke patients, many group exercise programs have been introduced in the community based on motor learning. Leroux reported that chronic stroke patients exhibited significantly improved balance, movement control, and gait after an 8-week group exercise program[10]. Pang et al. also reported on TOCT that focused on the upper extremities the program was composed of hand activities and functional training including range of motion movements, weight-bearing activities, and elbow and wrist exercises to improve upper extremity function in persons with chronic stroke[11].

Previous Korean studies reported that TOCT in stroke patients improved balance (measured via the Berg Balance Scale [BBS]) and ADLs (measured via the Modified Barthel Index[MBI]) when compared to a control group[12] furthermore, improvement in quality of life after community gait training was reported[13].

There have not been many previous reports of combination ADL training and gait training in group TOCT. In particular, there has not been a study that examined ADLs after training through an objective assessment measure. Therefore, the purpose of this study was to examine changes in motor function, ADL, and quality of life in chronic stroke patients after physical and occupational therapy through a group TOCT program.

2. Methods

2.1 Participants

Six hemiplegic participants who had experienced stroke (9 males, 3 females) were included in this study. Information regarding the purpose and method of this study was provided and consent was obtained. The inclusion criteria for the participants were as follows: (1) were in chronic stage of stroke recovery (ie, poststroke duration of ≥1y); (2) no other musculoskeletal disorders or neuromuscular diseases except stroke; (3) no problems with clear communication or cognition (score >18 on the Korean Mini-mental State Examination; (4) no participation in any rehabilitation program except the one developed for this study. Exclusion criteria were

[Table 1] General characteristics of subjects (N=6)

S.	Age (years)	Sex	Time since stroke (years)	Affected side	Walking aid	MMSE-K	Type of stroke
1	54	M	8.3	Rt.	None	29	CI
2	64	M	5.1	Lt.	Cane	26	CH
3	66	M	3.1	Rt.	Cane	30	CH
4	57	M	4.1	Rt.	None	21	CI
5	67	M	14.0	Lt.	Cane	23	CH
6	31	F	6.0	Lt.	None	30	CI

S; subject, CI; Cerebral Infarction, CH; Cerebral Hemorrhage, MMSE-K; the Korean Mini-Mental State Examination

(1) previous participation in a group TOCT exercise class prior to the beginning of the study; (2) any medical conditions that would severely limit participation in the exercise program or that could interfere with outcome assessments performed in the study[8]. The study period was 31 weeks and the general characteristics of the participants were presented in Table 1.

2.2 Outcome measures

Participants were evaluated on two occasions: (1) before initiating the exercise program and (2) at the end of the 31-week period. The tests employed to measure motor performance pre- and post-intervention have all shown a high level of validity and reliability.

2.2.1 Chedoke-McMaster Stroke Assessment (CMSA)

The CMSA includes 21 items divided into two inventories: impairment and disability. This tool is composed of 6 items that address shoulder pain, postural control, arm, hand, leg, and foot. A score ranging from 1 to 7 is assigned to each item with the total possible score ranging from 6 to 42. The disability inventory includes 2 dimensions: a gross motor function score ranging from 10 to 70 and a walking score ranging from 4 to 30 total scores range from 14 to 100. The inter-rater reliability has been established with an intraclass coefficients (ICC) of 0.98 (95% confidence interval) [14].

2.2.2 The Berg Balance Scale (BBS)

The BBS includes 14 items that measure static and dynamic balance and consists of various balancing tasks while sitting and standing. The BBS includes tasks such as getting up from a chair, moving from a chair to a bed, and standing on one leg. Each item is graded from 0-4 points with a maximum score of 56 points. Intra-rater reliability and inter-rater reliability are r=0.94-0.98, r=0.93-0.95, respectively, thus indicating high reliability and high internal validity[12].

2.2.3 The Assessment of Motor and Process Skill (AMPS)

The AMPS is an observational assessment used to evaluate people in the context of familiar and relevant tasks in basic and instrumental daily activities. The tool is a standardized assessment that can be used in those aged three years or older with any diagnosis or disability. The AMPS measures the performance of 23 ADLs based on a variety of tasks used in the assessment.

There are 13 major groups, such as meal preparation, table setting, and laundry, among others. During the task, 16 motor and 20 process skills are scored on a 4-point scale from 1 (an unacceptable amount of effort or inefficiency, imminent safety risk, or need for assistance was noted) to 4 (no problems observed with this skill in this task). The validity and reliability of this tool have been previously documented[16].

2.2.4 The Stroke Impact Scale (SIS)

The SIS 2.0 contains 64 items among eight domains: strength, hand function, mobility, ADL/IADL, memory, communication, emotion, and participation, in addition to a patient-reported percentage of recovery. Scores from 0 (extreme impact) to 100 (no impact) are separately recorded for each domain and the percentage of recovery. The reliability of the SIS is good, with Cronbach's alpha coefficients of 0.83 to 0.96, and ICC between 0.70 and 0.95[17].

2.3 Intervention

Each exercise session included brief (5-10 min) warm-up and cool-down periods in which the participants performed extremity stretches and active or self-assisted range of motion exercises. The 12 workstations incorporated into the circuit were: (1) physical therapy (6 workstations) and (2) occupational therapy (6 workstations). For further details on the training protocol, see the appendix. Among 12 workstations, training at 4 workstations included demonstration by a therapist.

The purpose of this study was improvement of gait and ADLs using a group circuit exercise program led by physical and occupational therapists. A total of 6 research team members comprising physical therapists, occupational therapists and physical therapy student assistants were assigned to 2 groups of 6 stroke patients, led by 2 therapists. The students that participated were well educated in TOCT, functional ability of the subjects, and the applied therapy methods prior to the study. The exercise program was conducted for 31 weeks, once a week, for 100 minutes.

During exercises, participants received extensive feedback from the class instructor on how to perform movements correctly and on appropriate posture. The level of difficulty of the exercises was modified by progressively increasing the number of repetitions and/or increasing the complexity of the exercises performed at each station[18].

2.4 Data Analysis

In this study, Wilcoxon's signed rank test was used to verify changes in the factors assessed (CMSA, BBS, SIS) pre and post-intervention and SPSS version 12.0 (SPSS Inc., Chicago, IL, USA) was used for analysis with a significance level of 0.05. A multi-faceted Rasch computer program (FACETS) was used to derive AMPS IADL motor and process ability measures[19].

3. Results

3.1 Exercise Program Participation

The participants showed a very high participation rate of 97% in the 31-week exercise program. Participants with a participation rate below 95% were excluded from this study.

3.2 Motor Performance Measures

Impairment CMSA scores were significantly improved after TOCT, while there was no difference in disability scores. After TOCT, there was a significant improvement in the BBS scores of the subjects [Table 2].

[Table 2] Comparison of pre- and post-intervention COMS and BBS scores (N=6)

Test	Pre - TOCT	Post- TOCT	Z	P
CMSA (Impairment)	21.66±4.27[a]	25.00±5.62	-2.236	0.025*
CMSA (Disability)	76.50±19.94	77.66±20.04	-1.633	0.102
BBS	34.66±16.42	39.16±17.75	-2.207	0.27*

[a]Mean±SD, *p<0.05, TOCT : task-oriented circuit training
CMSA ; Chedoke-McMaster Stroke Assessment, BBS; Berg Balance Scale.

[Table 3] Comparison of pre- and post-intervention AMPS scores (N=6)

Pt	Motor			Process		
	Pre-TOCT	Post-TOCT	Variation	Pre-TOCT	Post-TOCT	Variation
1	0.37	0.72	0.35*	1.29	1.07	-0.22
2	-0.99	-1.38	-0.39	-0.84	0.01	0.85†
3	-0.10	0.41	0.51†	-0.34	0.03	0.37*
4	0.04	0.62	0.58†	0.34	0.82	0.48*
5	0.12	-0.62	-0.74	0.30	0.94	0.64†
6	1.16	0.70	-0.46	1.17	0.02	-1.15

*Clinically meaningful change: logit=0.3~0.4, † Statistically significant change: logit >0.5
Assessment of Motor and Process Skill; AMPS

[Table 4] Comparison of pre- and post-intervention Stroke Impact Scale scores (N=6)

Items	Pre - TOCT	Post- TOCT	Z	P
Strength	7.83±1.16[a]	8.83±1.72	-1.732	0.083
Memory & Thinking	26.16±6.79	27.6±6.5	-1.633	0.102
Mood & Emotion	31.6±6.88	34.83±6.33	-2.032	0.042*
Communication	27.33±6.12	27.00±8.09	.000	1.000
ADL	32.33±4.63	34.66±6.47	-1.473	0.141
Mobility	31.50±10.94	31.83±10.55	-.557	0.557
Hand Function	6.00±2.00	6.00±2.00	.000	1.000
Social Participation	21.83±5.11	21.83±5.07	.000	1.000

[a]mean±SD, *p<0.05, TOCT ; task-oriented circuit training.

3.3 Assessment of Motor and Process Skills

There was a statistically significant increase greater than 0.5 logits in more than two subjects in the motor skill areas of AMPS in ADLs after TOCT. Another subject showed an increase greater than 0.3 logits. There were no notable changes in the other three subjects. In the process skills areas of AMPS in ADLs, two subjects showed a statistically significant increase greater than 0.5 logits, while there was a greater than 0.3 logit increase in the other two subjects, and no changes in the remaining two subjects [Table 3].

3.4 Stroke Impact Scale

There were significant increases in the SIS areas of mood and emotion after TOCT, but no changes were observed in strength, memory and thinking, communication, ADLs, mobility, or participation in society [Table 4].

4. Discussion

This study sought to evaluate changes in motor function, ADLs, and quality of life in stroke patients after TOCT in conjunction with physical and occupational therapy with the goal of improving motor performance and ADL performance. When hemiparetic patients complete their rehabilitation, the functional gains attributable to their therapy are often reduced or lost because of a reduced level of physical activity[1]. The participants exhibited significant improvement in impairment, static and dynamic balance, and mood and emotion after group TOCT intervention. However, there were no significant improvements in disability, strength, memory and thinking, communication, ADLs, mobility, hand function or social participation after group TOCT intervention in this study.

Improvement in motor performance and ADLs in chronic stroke patients is a relatively new area of study within the field of rehabilitation. Our TOCT program comprised high-intensity, task-specific training that included several principles of experience-dependent neuroplasticity, such as specificity, repetition, and intensity. The eight different functional workstations used in this trial were goal-oriented, challenging, feasible, meaningful and relevant to patients' needs (i.e., not too easy, yet not too difficult). The participants completed each task with progressive intensity.

There are four categories for assessing the capacity for stroke recovery: "impairment" describes the symptoms of pathological conditions "disability" represents limitations in functional activities; "handicap" indicates limitations in a functional role; and "quality of life" refers to a patient's physical, psychological, and social wellness[20]. In this study, the CMSA and BBS were used to assess motor function, the AMPS was used to assess impairments in ADLs, and the SIS was used to assess changes in impairment, disability, and quality of life. In response to TOCT, participants exhibited statistically significant improvement in motor function (as assessed by the CMSA), but significant changes did not occur in disability (as assessed by the SIS).

In this study, improvements in shoulder pain, postural control, and arm and leg ROM were observed via CMSA. This agrees with the study by Murie-Fernández (2012),where upper extremity physical therapy improved shoulder pain and ROM in stroke patients[21]. On the other hand, the lack of significant improvement in the disability area may be due to the long history of illness, ranging from 3 to 14 years, in chronic patients. Thirty-one weeks of therapy may have posed difficulties in significantly improving disability[3].

There was also a statistically significant improvement in balance (as assessed by the BBS), which has previously been reported to be closely correlated with independent gait[22]. These results are similar to the improvement in motor function reported after group therapy in a study by Leroux (2005)[10]. Also, improvements in the BBS 10 m gait score and SIS mobility score were shown inother programs utilizing a similar weight-bearing treadmill[23]. According to several other investigators, body weight-supported treadmill training post-stroke increases functional independence and gait speed[23,24]. There appears to be a strong neurophysiological basis to this type of retraining. In addition to improvements in upper extremity function, French et al. showed that repetitive task-oriented training resulted in modest improvements in lower limb function[25].

In this study, general improvements in motor and process areas of the AMPS were observed. These results also agree with previous studies that have found that task-oriented activities can be generalized into ADL abilities [12]. According to a review by Steultjens et al. (2003),sensorimotor training is not effective for improving ADLs, extended ADLs, social participation, or arm/hand function[26]. Nottingham extended the ADL scale, which improved in the control group than the circuit training group at 12 weeks[27]. These results agree with those of the current study.

Patients exhibited statistically significant improvements in moods and emotions, as measured by SIS assessment. The group exercise program gave patients a sense of belonging, fulfillment and problem solving that encouraged active participation in the exercises, motivated them, and instilled in them a sense of purpose, thereby encouraging further application of the program. White et al. (2014) reported that magnitude of pain and depression is negatively correlated with social status[28]. In general, group exercise improves social adaptability and decreases psychological sense of loss. Encouragement from other participants provides psychological stability, thus further encouraging its effectiveness as a therapeutic method[13]. Functional disability, depression, and lack of self-support are major factors that decrease quality of life in stroke patients. In Korea, several studies have indicated that depression, ADLs, functional status, social status, and motivation are factors that influence patient quality of life. A group circuit exercise program can be less costly and more effective for motor function improvement, and can provide more psychological satisfaction compared to individual therapies. Thus, group therapy can be a viable alternative for maintaining continued rehabilitation in chronic stroke patients.

This study enrolled chronic stroke patients in physical and occupational therapy to examine the effects on ADLs and quality of life. It is difficult to provide a comprehensive service that compiles information and opinions from various health care professionals because different professionals assess and treat patients independently. This study had the advantage of compiling recommendations from both physical and occupational therapists during assessment and with regard to program strategy development to create a more comprehensive intervention plan. According to the most recent clinical practice guidelines published by the American Heart Association, a multidisciplinary approach to stroke patient rehabilitation coordinated and carried out in an organized manner is recommended[29].

This pilot study had some limitations. First, our small and heterogeneous sample prevented us from drawing definite inferences from this analysis. A further study involving more patients is recommended. With the increasing elderly population and the growing cost of individual therapies, more studies on group therapies should be conducted that emphasize everyday physical functions and quality of life in stroke patients.

Appendix :

The Protocol of Task-oriented Circuit Training

1. Patients per group: 6
2. No. of therapists: 2 (an experienced physiotherapist and an occupational therapist)
3. Intensity (I): 31 weeks, 1 day per week, 100 minutes
4. Progression (P): increasing the number of repetitions completed in 40 minutes at a workstation and increasing treadmill speed
5. Warm-up Exercise: Extension exercises using a ball, steps and the wall, upper extremity stretches and active or self-assisted range of motion exercises (5-10 minutes)
6. Main Exercise - Physical Therapy: The following physical therapy exercises were conducted for 40 minutes
(2 workstations x 20 minutes each). (Fig. 1):

(1) Balance (maintenance of balance with the paretic leg on a step and the non-paretic leg suspended off the step and vice versa)

(2) Walking (forward, sideways, backwards, up and down stairs, outdoor, crossing a crosswalk, tandem stance and tandem walking)

(3) Partial weight support treadmill (partial weight support treadmill training, walking up to 30 minutes at a speed between 0.9 and 2.9 km/h, with a speed increase in 0.5-1.3 km/h each session. The speed was self selected by the subject)

(4) Strength training (elastic bands, balls, anti-gravity posture exercise, passive resistance exercise)

(5) Computer game (lower extremity symmetrical weight bearing using Nintendo Wii Sports Games)

(6) Functional task exercise (soccer, table tennis, dance)

7. Main Exercise - Occupational Therapy: The following occupational therapy exercises were conducted for 40 minutes (2 workstations x 20 minutes):

(1) Functional ADL training: using the telephone, cooking, drinking from a cup, brushing hair, brushing teeth, vacuuming, dressing and undressing, writing a letter.

(2) Upper range of motion (sling, ball, shoulder joint external rotation, functional electrical stimulation of the wrist extensor) passive or self-assisted range of motion for joints with no or minimal active movement using a sling or ball

(3) Sensory stimulation (guessing the object by proprioception and tactile sensation only, various sensory balls, grain vibrator on the palmar and extensor muscles of the hand, and various tactile stimuli

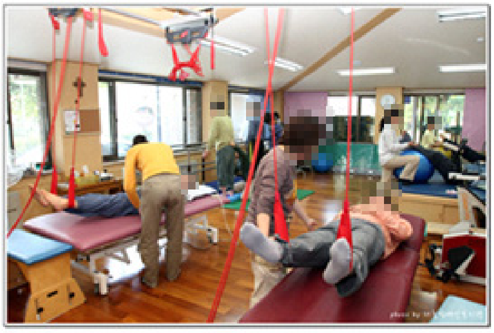
(4) Muscle strengthening (elastic band, putty, anti-gravity posture exercise, passive resistance exercise,

functional electrical stimulation to wrist extensors (only for those with less than 20f active wrist extension)

(5) Constraint-induced movement therapy (task completion using only the affected side with a splint applied to the less affected arm). Tasks such as preparing tea, putting on makeup, putting beans into a cup, Wii games, eating fruits, and ball rolling were done using only the affected side.

(6) Functional task training (Go-Stop card game, Korean traditional board game, general board game, writing a letter, gardening, typing on a computer, memory game) (Fig. 2)

8. Cool-down Period: Cool down in a seated position for 10 minutes, devoted to flexibility and range of motion exercises[8]



[Fig. 1] Physical therapy setting

[Fig. 2] Go-Stop card game (a task oriented game).

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