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Neuroplasticity and Functional Gains with Task-Specific Circuit Training in Stroke Patients

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Abstract

Objective: The objective of this research was to investigate the efficacy of task-specific circuit training in rehabilitating upper extremity rehabilitation in patients with middle cerebral artery (MCA) stroke. **Background**: Stroke is a leading health problem worldwide and often results in long-term disabilities, including the loss of upper limb function. Limitations in mobility following a stroke can lead to reduced physical activity levels. The impact of task-specific circuit training, an intervention method that emphasizes the practice of functional tasks, on the upper extremity function of individuals who have experienced a stroke in the middle cerebral artery (MCA).

Methodology:A pilot study with a pre-post test study design was conducted at the outpatient physiotherapy department of ACS Medical College and Hospital. To select participants, a random sampling method was employed, resulting in a sample of 10 stroke patients aged between 40 and 65 years. The inclusion criteria consisted of individuals who had suffered their initial stroke within the past 2-6 months, had experienced a first unilateral infarction, and exhibited a Brunnstrom stage of recovery in the proximal and distal regions of the affected upper extremity of 3 or below.

Both males and females were included in the study. Patients with cognitive impairment, dementia, previous orthopedic or neurological problems affecting the upper limb (e.g., severe arthritis, polyneuritis), severe heart disease, and other adverse health conditions that might affect their performance in the intervention (e.g., vestibular disturbance) were excluded. The intervention comprised a 12-week program combining task-specific circuit training with conventional physiotherapy. Participants engaged in training sessions five times per week, each lasting 40 minutes, while conventional physiotherapy sessions lasted 20 minutes per session over the same duration. The research utilized the Chedoke Arm and Hand Activity Inventory Scale (CAHAI-13) and electromyography (EMG) to assess the results.

Results: The findings revealed a significant and substantial disparity in average CAHAI-13 scores within the task-specific circuit training group, with the pre-test average being 48.50 and the post-test average being 51.50. This difference was highly significant, leading us to reject the null hypothesis with a p-value of less than or equal to 0.001**.** The results of the post-test assessments demonstrated a noticeable enhancement in upper limb function when compared to the pre-test measurements. Likewise, the EMG scores for the biceps, triceps, extensor digitorum, and deltoid (middle) exhibited highly significant differences within the task-specific circuit training group between the pre-test (585.38, 271.63, 389.00, 668.00) and post-test (456.50, 187.63, 266.00, 512.38), leading to the rejection of the null hypothesis ($p \leq 0.001$). Moreover, there were extremely notable differences within the same group between the initial assessment and subsequent evaluation ($p \leq 0.001$).

Conclusion: To summarize, the research determined task-specific circuit training was successful in improving upper limb function among individuals who had experienced an MCA stroke. The results, which were reinforced by notable enhancements in CAHAI-13 scores and EMG measurements, underscore the promising potential of task-specific circuit training as an successful treatment for rehabilitating the upper extremities of MCA CVA patients.

Keywords: stroke, task specific circuit training, Chedoke Arm and Hand Inventory Scale, Electromyography, middle cerebral artery.

1. Introduction

Stroke is a prominent factor contributing to prolonged impairment and disability, often necessitates assistance in daily mobility tasks for survivors. Repetition plays a crucial role in motor training, as practice is key to improving performance. Behavioral experiences can stimulate neuroplastic changes in the brain, but engaging neural circuits alone is insufficient for promoting lasting plasticity. It is necessary to repeat newly learned or relearned behaviors to induce enduring neural modifications. While changes in cortical organization resulting from behavioral interventions are encouraging, the practice required for central reorganization presents a challenge for rehabilitation professionals, given the disparity between this requirement and current clinical practice. (1)

Stroke has emerged as a significant health concern in India, as the average lifespan has surpassed 60 years. Consequently, age-related ailments, including stroke, have seen a considerable increase, making it the fourth most prevalent cause of death and the fifth most prevalent cause of disability in the country. (2)Looking at the global picture, stroke stands as the second most prominent cause of both mortality and disability.(3)

Ischemia is the primary underlying factor in the majority of strokes, accounting for approximately 85% of cases, which is primarily attributed to conditions such as arteriolosclerosis affecting small blood vessels, athero-thromboembolism affecting large arteries, and cardio-embolism. Around 15% of strokes globally are caused by intracerebral hemorrhage, which can occur in different parts of the brain like the basal ganglia, brainstem, cerebellum, or cerebral lobes.(4) When a stroke occurs, noticeable impairments arise, leading to limitations and changes in functional mobility and performance of tasks involving the affected upper and lower extremities.(5)

There are two primary classifications of stroke: hemorrhagic and ischemic. Hypertension not only elevates the risk of hemorrhagic stroke but also contributes to the progression of atherosclerotic disease, which can ultimately result in ischemic stroke. Hyperlipidemia is a significant risk factor for strokes caused by atherosclerosis in both the blood vessels outside and inside the brain, as well as for coronary atherosclerosis. Atrial fibrillation can give rise to cardio-embolic stroke.(6)

The extent of impairment caused by different types of strokes can vary, leading to challenges in various aspects of daily life such as performing everyday tasks, learning, maintaining body posture and position, walking, maintaining balance, and interacting with others. (7)Upper-limb weakness is a commonly observed condition during both the early and long-term phases of stroke rehabilitation. In fact, studies suggest that around 40% of individuals are unable to regain functional use of their upper limbs for everyday activities.(8)

Task-specific intensive practice has been shown to promote favorable neuroplastic changes following a stroke. One approach that has gained recognition is circuit training, which involves repetitive and targeted exercises focused on specific tasks. During circuit training, participants engage in a series of progressive functional exercises either at different workstations or through customized exercise routines.(9)

Functional recovery following a stroke primarily relies on neuroplasticity, which refers to the injured brain's ability to recover and repair. (10,11) The Chedoke Arm and Hand Activity Inventory (CAHAI) was carefully developed to incorporate relevant functional tasks that correspond to the World Health Organization's definition of activities and to accurately detect significant changes in upper-limb function in a clinical setting. Hemiplegia, a condition where one side of the body is paralyzed, is experienced by over 85% of stroke patients, and among them, more than 69% face difficulties with motor function in their upper limbs. It is important to note that the upper extremities are more adversely affected compared to the lower extremities. Approximately 75% of all strokes are caused by damage to the middle cerebral artery, which supplies blood to the brain region responsible for motor functions in the upper extremities and hands. (12) Electromyography (EMG) biofeedback is a technique that offers immediate visual and auditory feedback regarding muscle contraction and movement. This technology effectively aids in promoting correct muscle activation, proper body alignment, and normal movement patterns. It enables patients to gain awareness of their muscle tone and learn to make adjustments accordingly. Despite its potential benefits, the integration of EMG biofeedback in stroke treatment has not been uniformly implemented across various therapeutic interventions until recent times.(13)

Circuit training serves as a systematic and gradual training method that controls the intensity of the exercises, allowing for repeated training of a wide range of tasks. The effects of task-specific circuit training on upper extremity function and activities of daily living (ADL) in acute stroke patients have not been thoroughly investigated, leading to a lack of clarity regarding its specific impact. Consequently, the aim of this study was to assess the effects of task-specific circuit training on upper extremity function in individuals who recently experienced a stroke.

2. Materials and Methods

2.1 Participants

A preliminary investigation was carried out at ACS Medical College and Hospital, involving a group of 10 patients who had experienced a middle cerebral artery (MCA) stroke. The participants for the study were selected using a random sampling method.

2.2 Research Design

This study can be characterized as a pre- and post-type study with a duration of 12 weeks, involving sessions held 5 days a week. Individuals experiencing a first-time stroke within the onset period of 2-6 months, aged between 45-70 years, with unilateral cerebral infarctions, and with a Brunnstrom stage of recovery scoring 3 or below. Both male and female participants were included in the study.

However, individuals with cognitive impairment, Parkinson's disease, severe cardiovascular disease, vestibular disturbance, previous orthopedic or neurological problems affecting the upper limb (such as severe arthritis or polyneuritis) were excluded from the study.

Subjects were selected based on the above mentioned criteria and received conventional physiotherapy interventions, which involved active and passive movements, stretching, balance and coordination exercises, strengthening exercises, mat activities, and conventional physiotherapy exercise training. Additionally, task-specific circuit exercises were administered at different workstations, focusing on prehension, precision, dexterity, strength, control of the upper extremity, and advanced motor tasks. The total duration of therapy sessions was approximately one hour, held 5 days a week for 12 weeks. Initially, 10 subjects were included in the study; however, due to clinical issues, 2 subjects were subsequently excluded.

2.3 Procedure

Subjects were chosen based on specific criteria for selection. The individuals received a standard physiotherapy treatment that involved both active and passive movement, stretching, balance and coordination exercises, strengthening exercises, and mat activities. Additionally, they underwent conventional physiotherapy exercise training and task-specific exercises at different workstations. These exercises included reaching, gripping, and transferring light objects, as well as precision, dexterity, strength, and control exercises for the upper extremities, including advanced motor tasks. The treatment duration was approximately one hour per session, conducted five days a week for a period of 12 weeks. Initially, there were 10 subjects included in the study, but due to clinical issues, two subjects were excluded.

The training sessions commenced with 20 minutes of conventional physiotherapy, followed by 40 minutes of task-specific exercises at Workstation 1. The workstations were changed every two weeks, and each new workstation included exercises specific to that particular week, as well as incorporating exercises from previous workstations.

To assess the improvement in muscle contraction, NORAXON EMG (Kinesiological pure sensor wireless EMG) was utilized to detect muscle activity in the selected subjects. Surface electrodes were placed on the targeted muscles, which included the Deltoid, Biceps brachii, Triceps, Wrist flexors, and Extensors. Muscle contraction was evaluated both before and after the intervention to measure any enhancements in muscle contraction.

2.4 Intervention

The rehabilitation program included a comprehensive range of motion (ROM) exercises for the upper limb, which consisted of both passive and active-assisted movements. Additionally, common mat activities were incorporated into the routine. The program also focused on prolonged and gradually progressive stretching of specific muscle groups such as the biceps, triceps, wrist flexors and extensors, as well as finger extension. Following the stretching exercises, a task-specific circuit training was implemented, which involved five workstations.

Workstation 1 aimed at improving reaching, gripping, and transferring light objects. Workstation 2 focused on enhancing upper extremity strength and control. Workstation:3, targeted the improvement of grip, precision, and dexterity with the upper extremity. Workstation :4 , aimed at enhancing the control of the upper limb. Lastly, Workstation: 5,aimed at achieving advanced motor tasks with the upper extremity. After a duration of 12 weeks, post-test scores were collected from the patients and subjected to statistical analysis to evaluate the effectiveness of the rehabilitation program.

Work station 1

Actions intended to achieve the task of extending one's reach, grasping, and transferring lightweight objects:

Resting the arm on an elevated platform with the shoulder flexion at a 90-degree angle. Actively pushing little things (such a light items) off the edge of the plinth in order to hit the wall, Sitting in the Identical position to push a heavier ball, Active horizontal adduction and abduction to access the cup-shaped object on the wall, Wrist flexion/extension while counterbalancing gravity (set a goal), Ulnar and radial deviation with a push target (cup) in a gravity-balanced environment, Transferring and picking up light objects from a table.

Workstation 2

The objective is to enhance and improve control and strength in the upper extremities:

Active shoulder flexion, extension, and abduction while holding a water bottle weighing different sizes, attempting to grasp a cup located on the wall with active flexion, extension, and abduction the shoulders while wearing a resistance band, engaging in active shoulder abduction while holding weights of different sizes, reaching for a target (water bottle) positioned on the wall. Water bottle and active elbow flexion/extension, Active ulna/radial deviations and wrist flexion/extension, Rapid hand alternating movements.

Workstation 3

Objective to enhance grasping ability, fine motor control, and skillfulness of the upper limbs:

On the white board, draw a line**,** Engage in a back-and-forth motion with a water bottle on a flat surface or table, and alternate between opening and closing a window. Remove bottle lids, Insert and remove cash from a purse, Fold the paper, then put it in the envelope.

Workstation 4

Objective to develop proficient management of the upper extremity:

Perform finger-nose movements by touching a target on a wall or your partner's finger. Vary the distance and speed of the movements. Engage in rapid alternating movements on a table using pronation/supination. Clap your hands together. Touch targets of different sizes and distances, gradually increasing the speed. Trace various figures on a whiteboard. Bring objects of different sizes and weights from a table to your mouth. Utilize your protracted shoulder to open a door while standing three feet away from it.

Workstation *5*

Objective to attain high-level motor proficiency in performing tasks with the upper limb:

Engage in the action of rolling an object back and forth by pushing it. Reach out, grasp, and relocate objects to different heights. Perform wiping motions on windows. Wash, wring, and hang clothing on a clothesline. Paint sketched objects on cardboard paper. Utilize keyboards for typing purposes.

3. Data Analysis

The data that was collected underwent analysis using descriptive and inferential statistics. The statistical software utilized for this analysis was the social science package known as SPSS, specifically version 234. The paired t-test method was employed to determine any statistical distinctions within the groups, while the independent t-test (also known as the Student t-test) was utilized to identify any statistical distinctions between the groups.

Table 1. Comparison of Chedoke Arm and Hand Activity Inventory within the Group in Pre and Post Test

	PRE-TEST		POST-TEST		t-TEST	df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
TASK SPECIFIC CIRCUIT TRANING	48.50	2.777	51.50	3.381	-7.099	7	.000***

(*- P ≤ 0.001)**

The table provided displays the Mean, Standard Deviation (SD), t-value, and p-value comparing the pre-test and post-test results within the group. The analysis indicates a highly significant statistical difference between the pre-test and post-test values within the group (***, P ≤ 0.001).

Table 2. Comparison of Electromyogram in Biceps within the Group in Pre and Post Test

	PRE-TEST		POST-TEST		t-TEST	df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
TASK SPECIFIC CIRCUIT TRANING	585.38	22.909	456.50	42.126	10.578	7	.000***

Table 3. Comparison of Electromyogram in Triceps within the Group in Pre and Post Test

	PRE-TEST		POST-TEST		t-TEST	df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
TASK SPECIFIC CIRCUIT TRANING	271.63	10.197	187.63	7.170	16.658	7	.000***

Table 4. Comparison of Electromyogram in Deltoid within the Group in Pre and Post Test

	PRE-TEST		POST-TEST		t-TEST	Df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
TASK SPECIFIC CIRCUIT TRANING	389.00	14.909	266.00	32.187	15.726	7	.000***

Table 5. Comparison of Electromyogram in Extensor Digitorum within the Group in Pre and Post Test

	PRE-TEST		POST-TEST		t-TEST	df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			

TASK SPECIFIC CIRCUIT TRANING	668.00	12.012	512.38	23.201	16.934	7	.000***

4. Result

On comparing Chedoke Arm and Hand Inventory Scale (CAHAI-13) between Pre- test 48.50 and Post-test 51.50 mean values within Group (task specific circuit training) shows highly significant difference between Pre-test and Posttest mean values at $P \leq 0.001$.The Post-test values have shown improvement when compared with Pre- test. Hance the null hypothesis is rejected.

The comparison of Electromyography (EMG) scores for Biceps, Triceps, Extensor Digitorum, and Deltoid (Middle) between the Pre-test and Post-test within the Group (task-specific circuit training) revealed a significant difference. The mean values of the Pre-test scores (585.38, 271.63, 389.00, and 668.00) and the Post-test scores (456.50, 187.63, 266.00, and 512.38) showed a highly significant improvement at a significance level of $P \leq 0.001$. Therefore, we reject the null hypothesis, indicating that the Post-test scores were significantly better compared to the Pre-test scores.

5. Discussion

The study aimed to investigate and analyze the ways how effective task-specific circuit training (TSCT) is for rehabilitating the upper extremities of stroke patients with middle cerebral artery (MCA) stroke.. In our pilot study, combining TSCT with conventional physiotherapy demonstrated positive outcomes, including a reduction in spasticity and improvements in motor function and functional activity. The exercises employed in our study were both simple and effective in achieving these outcomes.

In 2009, a research conducted by Ingrid GL van de Port et al. revealed that TSCT demonstrated effectiveness for 220 stroke patients at various centers, demonstrating cost-effectiveness.. The key features of the task-oriented CCT program were the gradual increase in intensity and the specific tasks performed at each workstation(14)

Additionally, Catherine M. Dean et al. (2000) reported the feasibility of conducting an exercise class for a group of chronic stroke patients with varying levels of functional abilities(15)Lotte Wevers and colleagues (2022) found evidence supporting the effectiveness of task-oriented circuit class training in improving gait and related activities in individuals with chronic stroke. However, additional research is required to examine the cost-effectiveness of this approach and its effectiveness during the early recovery phase of stroke, taking into account any comorbidities that may be present. Furthermore, it is important to investigate strategies for assisting individuals in sustaining and enhancing their physical capabilities once their rehabilitation program conclude..(16)

Coralie K. English et al. conducted a study in 2007 and discovered that Circuit class therapy showed similar effectiveness to individual physical therapy sessions in a cohort of individuals receiving inpatient rehabilitation following a stroke. The study's findings, which indicated improved walking independence and high levels of patient satisfaction, suggest that the utilization of circuit classes as a means of delivering rehabilitation services merits additional exploration.(17) Therefore, the study demonstrated that the administration of TSCT resulted in enhanced upper limb function.

In their study, Ko et al. (2015) found that three subjects showed improvement in the motor area, as indicated by the Assessment of Motor and Process Skill results. Additionally, four subjects demonstrated improvement in the process area. These findings suggest that TOCT can have positive effects on the Motor proficiency of Long-term hemiplegic stroke survivors residing in the community. (18)According to a study by Jong-Hoon Moon et al. (2018), the TOCT group exhibited noteworthy advancements in terms of motor activity utilization and a higher stroke impact score compared to the neurodevelopmental treatment group, suggesting a significant recovery ($p < 0.05$). This indicates that implementing the TOCT program, which involves the use of therapeutic tools, may have a beneficial effect on the utilization of enhance their motor function and abilities in their arms and hands.(19)

The study conducted by Isa U. Lawal et al. in 2015 aimed to determine if extending the duration of Circuit Class Therapy would result in improved motor function recovery among individuals who had experienced a stroke.[20]

In a study conducted by da Silva, Paulo Bazile, and colleagues in 2015, they explored the effects of incorporating strength training into a task-oriented rehabilitation program for individuals with chronic hemiparesis after stroke. The study's results revealed that the incorporation of muscle strength training yielded notable improvements in upper-limb rehabilitation. The TOT_ST group consistently outperformed other groups in the majority of assessed parameters, indicating the significant benefits of incorporating loaded exercises into a task-oriented training regimen. These findings imply that the inclusion of strength exercises within a task-oriented program could be instrumental in enhancing upper-limb function among chronic stroke patients with mild impairment.(21)

Recurrence training of the upper extremities through Task specific Circuit Training proved advantageous in the ongoing study, promoting patients' recovery and brain reorganization. Initiating rehabilitation as early as possible enhances the prognosis for individuals experiencing an acute stroke.

6. Conclusion

The study's findings indicated that Task-Specific Circuit Training (TSCT) was successful in enhancing upper limb function in individuals who had experienced an MCA Stroke. When combined with Conventional therapy, TSCT demonstrated notable improvements in the Chedoke Arm and Hand Activity Inventory Scale (CAHAI-13) and Electromyogram assessments.

Institutional Review Board Statement

Ethics Review Committee Declaration (IRB)of the Faculty of Physiotherapy MPT(Neuro)-05/PHYSIO/IRB/2021-2022 carried out an ethical evaluation. All procedures were conducted following the ethical guidelines set by both the responsible ethics committee at the institutional and national levels regarding human experimentation, as well as the Helsinki Declaration study of 1964 (revised in 2008).

Informed Consent

All participants included in the study provided their informed consent.

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Conflicts of Interest

The authors have no conflicts of interest to declare.

Reference

1. Rose, D., Paris, T., Crews, E., Wu, S. S., Sun, A., Behrman, A. L., et al. (2011). Feasibility and effectiveness of circuit training in acute stroke rehabilitation. *Neurorehabilitation and neural repair*, *25*(2), 140–148. https://doi.org/10.1177/1545968310384270
2. Jones, S. P., Baqai, K., Clegg, A., Georgiou, R., Harris, C., Holland, E. J., et al(2022). Stroke in India: A systematic review of the incidence, prevalence, and case fatality. *International journal of stroke : official journal of the International Stroke Society*, *17*(2), 132–140. https://doi.org/10.1177/17474930211027834
3. Kamalakannan, S., Gudlavalleti, A. S. V., Gudlavalleti, V. S. M., Goenka, S., & Kuper, H. (2017). Incidence & prevalence of stroke in India: A systematic review. *The Indian journal of medical research*, *146*(2), 175–185. https://doi.org/10.4103/ijmr.IJMR_516_15
4. Murphy, S. J., & Werring, D. J. (2020). Stroke: causes and clinical features. *Medicine (Abingdon, England : UK ed.)*, *48*(9), 561–566. https://doi.org/10.1016/j.mpmed.2020.06.002

5. Emmanuel Frimpong C. Antwi-Boasiako, O. Olawale (2016) Effects of Task-Oriented Circuit Class Training on Physical Fitness of Stroke Survivors. Journal of Exercise Science & Physiotherapy, Vol. 12, No. 2. DOI:10.18376/jesp/2016/v12/i2/111259
6. Boehme, A. K., Esenwa, C., & Elkind, M. S. (2017). Stroke Risk Factors, Genetics, and Prevention. *Circulation research*, *120*(3),472–495. https://doi. Org / 10.1161 / CIRCRESAHA .116.308398
7. kanase, suraj. (2023). Effect of Endurance Training on Long-Term Stroke Survivors. *Journal of Ecophysiology and Occupational Health*, *23*(2), 89–92. https://doi.org/10.18311/jeoh/2023/33414
8. Harris, J. E., & Eng, J. J. (2010). Strength training improves upper-limb function in individuals with stroke: a meta-analysis. *Stroke*, *41*(1), 136–140. https://doi.org/10.1161/STROKEAHA.109.567438
9. English, C., Hillier, S. L., & Lynch, E. A. (2017). Circuit class therapy for improving mobility after stroke. *The Cochrane database of systematic reviews*, *6*(6), CD007513. https://doi.org/10.1002/14651858.CD007513.pub3
10. Thant, A. A., Wanpen, S., Nualnetr, N., Puntumetakul, R., Chatchawan, U., Hla, K. M., & Khin, M. T. (2019). Effects of task-oriented training on upper extremity functional performance in patients with sub-acute stroke: a randomized controlled trial. *Journal of physical therapy science*, *31*(1), 82–87. https://doi.org/10.1589/jpts.31.82
11. See J, Dodakian L, Chou C, et al. A Standardized Approach to the Fugl-Meyer Assessment and Its Implications for Clinical Trials. *Neurorehabilitation and Neural Repair*. 2013;27(8):732-741. doi:10.1177/1545968313491000
12. Barreca, S. R., Stratford, P. W., Lambert, C. L., Masters, L. M., & Streiner, D. L. (2005). Test-retest reliability, validity, and sensitivity of the Chedoke arm and hand activity inventory: a new measure of upper-limb function for survivors of stroke. *Archives of physical medicine and rehabilitation*, *86*(8), 1616–1622. https://doi.org/10.1016/j.apmr.2005.03.017
13. Kim J. H. (2017). The effects of training using EMG biofeedback on stroke patients upper extremity functions. *Journal of physical therapy science*, *29*(6), 1085–1088. https://doi.org/10.1589/jpts.29.1085
14. van de Port, I. G., Wevers, L. E., Lindeman, E., & Kwakkel, G. (2012). Effects of circuit training as alternative to usual physiotherapy after stroke: randomised controlled trial. *BMJ (Clinical research ed.)*, *344*, e2672. https://doi.org/10.1136/bmj.e2672
15. Dean, C. M., Richards, C. L., & Malouin, F. (2000). Task-related circuit training improves performance of locomotor tasks in chronic stroke: a randomized, controlled pilot trial. *Archives of physical medicine and rehabilitation*, *81*(4), 409–417. https://doi.org/10.1053/mr.2000.3839
16. Wevers, L., van de Port, I., Vermue, M., Mead, G., & Kwakkel, G. (2009). Effects of task-oriented circuit class training on walking competency after stroke: a systematic review. *Stroke*, *40*(7), 2450–2459. https://doi.org/10.1161/STROKEAHA.108.541946
17. English, C. K., Hillier, S. L., Stiller, K. R., & Warden-Flood, A. (2007). Circuit class therapy versus individual physiotherapy sessions during inpatient stroke rehabilitation: a controlled trial. *Archives of physical medicine and rehabilitation*, *88*(8), 955–963. https://doi.org/10.1016/j.apmr.2007.04.010
18. Myung-Sook Ko, Hye-Seon Jeon, Sujin Hwang (2015) Effects of Group Task- Oriented Circuit Training on Motor Function, ADLs and Quality of Life in Individuals with Chronic Stroke: A Case Study Journal of the Korea Academia- Industrial cooperation Society 16(3):1894-1903 DOI: 10.5762/KAIS.2015.16.3.1894
19. Moon, J. H., Park, K. Y., Kim, H. J., & Na, C. H. (2018). The Effects of Task-Oriented Circuit Training Using Rehabilitation Tools on the Upper-Extremity Functions and Daily Activities of Patients with Acute Stroke: A Randomized Controlled Pilot Trial. *Osong public health and research perspectives*, *9*(5), 225–230. https://doi.org/10.24171/j.phrp.2018.9.5.03
20. Lawal, I. U., Hillier, S. L., Hamzat, T. K., & Rhoda, A. (2015). Effectiveness of a structured circuit class therapy model in stroke rehabilitation: a protocol for a randomised controlled trial. *BMC neurology*, *15*, 88. https://doi.org/10.1186/s12883-015-0348-7
21. da Silva, Paulo Bazile et al. "Strength training associated with task-oriented training to enhance upper-limb motor function in elderly patients with mild impairment after stroke: a randomized controlled trial." *American journal of physical medicine & rehabilitation* vol. 94,1 (2015): 11-9. DOI: 10.1097/PHM.0000000000000135.