The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131 Volum XV issue 1/ 2022

# NEUROPLASTICITY: RECOVERY FUEL FOR UPPER LIMB PERFORMANCE DURING SUBACUTE PHASE AFTER STROKE

***PhD Student, Gabriela Iuliana Cazac*[1]**
University of Pitesti - IOSUD[1]
gabriela.cazac@usm.ro[1]

**Keywords: neuroplasticity, recovery, stroke, upper limb**

**Abstract**

All of us were born with a nervous system that isn't just capable of change but was designed to change. Harnessing and directing the power of brain plasticity is the focus of most of modern stroke specific rehabilitation but the point is how do we make the most out of this kind of rehabilitation in individuals spheres of functioning and how does neuroplasticity it apply to stroke recovery? The current paper has two primary aims. First this study will investigate the effectiveness of some specific recovery options that promote neuroplasticity on the upper extremity sensorimotor recovery during the subacute phase after a stroke. The second aim of this paper is to explore the effectiveness of mixing and matching recovery options in post stroke rehabilitation training. Finding the appropriate evidence-based recovery options and the correct mix is part science, part intuition and part experience.

## Introduction

When we talk about improvement or healing after stroke there are a lot of processes at play but they can kind of be bundled into two big concepts. The first process in healing is what is called diaschisis.When you have a stroke or an injury to the neurological system the surrounding cells aren't necessarily killed or damaged but they are temporarly knocked out, so you have this loss of function within a region that is peripheral to the side of the lesion [1]. The first process is the resolution of diaschisis and this is often when we see those larger jumps in function early in the rehabilitation process because we have these regions that are starting to metabolize correctly. This is known as spontaneous recovery [2, 3] and is vital to recognize because it is the harkening that the most important phase of recovery has begun, the subacute phase [3]. Once the first symptom of spontaneous recovery is recognized, the clock is ticking! During the subacute phase, the billions

of neurons that have survived the stroke become available to go back to work and the intensity and quality of effort during the subacute phase will ensure the highest level of recovery [3].

Once we have those neurons alive and working and we are left with the dead and damage cells from the stroke itself the primary mechanism and biological pathway to return of functional recovey after stroke is what is called neuroplasticity [4]. To support the brain potential of plasticity, the brain increases production of trophic (growth) factors (nerve growth factors, brain-derived neurotrophic factor and glial-derived neurotrophic factor) which enhance both the repair of injured structures and the creation of new neurological structures [11, 12, 13]. Specifically when we talk about stroke we talk about axonal growth markers of trophic factors in the contralesional area of the brain in the first week post stroke and increased expression of growth markers perilesional over the first 3 to 6 months post stroke [5, 6, 11, 12]. This is part of the reason why we look at early intervention in stroke because we want to take advantage of this increased growth marker phenomenon. There are specific windows of opportunity after stroke in which the brain is highly plastic and therefore the other key is the timing of intervention, too early (during hyperacute and subacute phases) can limit recovery and too late (during the chronic phase, sometimes defined as more than 3 months after stroke) the impact of recovery strategies will be limited [3]. During the subacute phase (the first 3 months) [9] the brain is awash in brain-derived neurotrophic factors and this is one of the reasons the subacute phase provides such unique opportunities for recovery [3].

Given the right circumstances the brain can radically rewire but there are some principles of neuroplasticity that we have to engage in recovery process. One of the proven ways to open up this magical thing that we call neuroplasticity is called *repetitive practice* [7, 8, 10]. Repetitive practice is essential to relearning a skill and means using the little movements you have to, over and over again and trying to hit the end range of that movement. We want to make sure that specific motor pattern is accurate first and than build on that movement by using high levels of repetition of that accurate motor patterns. How many repetitions is necessary to attempt a movement before we see improvement, tens of thousands, hundreds of thousands of repetitions? There is no specific number that will always answer this question because every stroke survivor is different for so many reasons. *Massed practice* [7, 10] matters, basically what is means is that recovery involves many hours a day of scheduled work and this is one of the reasons that working only when a therapist is around is not practical because is simply not enough time to accomplish that number of repetitions needed. In neurological rehabilitation we talk a lot about function and we talk about task specific function like toileting, eating, rolling in bad, gait and if we want those specific function to get better we

have to target those specific functions in the environments in which they occur, we need to work on that ultimate goal, it is not enough to work on things that are kind of like the ultimate goal. One of the techniques researchers use to promote robust recovery is called task specific training [8, 10]. Neuroplasticity is much more likely to occur if the movement we trying to relearn is a part of a real world task that is meaningful, that is relevant and engage that individuals attentional systems [8, 10].

The motivation, focus and awareness is an important piece because the patients have to pay conscious attention to the function they are completing in order to have access to neuroplastic change in the brain [7]. In stroke this can be a challenge aspects for physiotherapist because sometimes the stroke affects parts of the brain that are responsible for things like motivation, engagement and awareness and this cause an inherent challenge in the rehabilitation process. In stroke rehabilitation it takes time to build trust and we really need that therapeutic alliance to address awareness challenges. Every day tasks as therapy has to incorporate this concepts that form the foundation of stroke recovery: repetitive (doing the movement that you want to relearn over and over), task specific (having recovery efforts center on specific, real-world tasks), massed practice (dedicating multiple hours per day to your recovery effort) and motivation.

All this buzzword concepts are important to one thing: *recovery*. From my clinical experience stroke survivors typically regain arm movement in muscles and joints close to the body and move down the limp, toward the hand. The arm has a strong chance of recovering and here are some clinically proven stroke recovery options.

**Material-method**

The current paper has two primary aims. First this study will investigate the effectiveness of some specific recovery options that promote neuroplasticity on the upper extremity sensorimotor recovery during the subacute phase after a stroke. The second aim of this paper is to explore the effectiveness of mixing and matching recovery options in post stroke rehabilitation training. We stride to answer: addind a second option can amplify the efficiency of your recovery routine?

The subject of this paper was a 66-years old man diagnosed with a left side hemiparesis of the body after a right MCA territory ischemic stroke, with a Fugl-Meyer score of 52 right after the stroke. The recovery plan was applied at the patient home over a period about 3 months with a frequency of 5 sessions per week, each session lasted 60 minutes.

When we developing a strategy for recovery, we have to ask ourself some basic questions: It is the recovery options evidence-based? Is it safe? Is it challenging? If it is not evidence based why did you pick that recovery options? If is safe but not challenging, it will not produce results. If it is challenging but not

safe, there is a risk of injury, in this case, the option is worthy of consideration? I chose options that are evidence based, that are physically challenging but have little risk. These recovery options include:

- Bilateral Training;
- Task specific training;
- Neuromuscular electrical stimulation;
- Constraint-Induced Therapy for the Arm and Hand;
- Mirror Therapy;
- Virtual Reality;
- Proprioceptive neuromuscular facilitation (PNF).

The Fugl-Meyer assessment upper extremity scale (FMA-UE) was used to analyze the sensorimotor function improvement.


Fig. 1. Task specific training with NMES, verbal commands, tactile, visual cues, in this case, NMES activates the muscles that open the hand.

**Results**

In table 1 are presented the results based on the Fugl-Meyer scale assessment of sensorimotor function for upper extremity, wrist, hand, coordination and speed, sensation, passive joint motion and joint pain right after the stroke and after 3 months physical therapy.

Table 1 Fugl-Meyer Assesment Upper Extremity

| Assessment of sensorimotor function | FMA-UE right after the stroke | FMA-UE after 3 months therapy |
|---|---|---|
| A.Upper extremity | 12/36 | 28/36 |
| B.Wrist | 2/10 | 8/10 |
| C.Hand | 4/14 | 12/14 |

| | | |
|---|---|---|
| D.Coordination/Speed | 1/6 | 5/6 |
| Total A-D (motor function) | 19/66 | 53/66 |
| H.Sensation | 4/12 | 8/12 |
| J.Passive joint motion | 13/24 | 22/24 |
| J. Joint pain | 16/24 | 23/24 |
| Total score FMA-UE | 52/126 | 106/126 |

**Discussions**

As we can see in the table from above, significant differences were revealed in all domains of Fugl-Meyer sensorimotor function. The patient had recovered remarkable well but compared with ipsilesional hand, the affected hand still remained somewhat impaired, with a slightly reduced dexterity and slowed movement on finger movement sequences. The subacute phase is a time of a great hope for many stroke survivors and the huge influx of neurons allow the survivor to recover at a rapid pace. All the evidence based recovery options have the potential of provindind a small amount of voluntary movement, once we have an acurrate small voluntary movement, we use that movement repetitively. Once repetitive practice provides enough movement you can build on that movement a specific task.

Some things are just better together even when we talk about recovery options. One option at a time can work well, but sometimes adding a second option can magnify and complement both. These recovery options can include: NMES (neuromuscular electrical stimulation) & task specific, task specific & PNF, constraint-induced therapy for the arm and hand & task specific, bilateral training & NMES, mirror therapy & NMES, VR-therapy & bilateral training, VR-therapy & task specific.

What precautions should be taken? There are some limitations and some variables we need to consider when we mixing and matching therapies: type of health issues that are unrelated to the stroke (heart problemns like atrial fibrillation, diabetes, depression, cardiac pacemaker, etc.), the type and number of conditions related to the stroke (loss of feeling, unilateral neglect, apraxia, aphasia, spasticity, etc.), type of stroke and side of damage (if the stroke affected the dominant or nondominant side), the amount of movement you have, how long after the stroke it has been and in which phase of recovery you are (some options work well right after the stroke but other options are best tried in the chronic stage of recovery), dosage, motivation and awareness level, etc.

**Conclusions**

The bottom line is that recovery from stroke is hard work, the movements and tasks that are new (new since the stroke) are difficult and challenging,

neuroplasticity takes a lot of energy, a lot of time, concentration, and focus. The hallmark of a stroke survivor is that in order to rewiring there nervous system, they have to engage in a completely different and specific set of processes in order to get those changes to occur and for them more importantly to stick around. Look closey for matching recovery options correctly because that can amplify the efficiency of recovery.

**References**

[1]. Carrera, E., Tononi, G. (2014). Diaschisis: past, present, future. *Brain,* 137(9), 2408-2422. https://doi.org/10.1093/brain/awu101

[2]. Jones T. A. (2017). Motor compensation and its effects on neural reorganization after stroke. *Nature reviews. Neuroscience*, *18*(5), 267–280. https://doi.org/10.1038/nrn.2017.26

[3] Levine, P. G. (2012). Stronger after stroke. Your Roadmap to Recovery. New York: Demos Health Publisher, p. 137-140, 16-18, retrieved from https://b-ok.xyz/book/2189498/151f09

[4]. Su Fan, Xu Wendong (2020). Enhancing Brain Plasticity to Promote Stroke Recovery. *Frontiers in Neurology,* Volume 11, ISSN 1664-2295. https://doi.org/10.3389/fneur.2020.554089

[5]. Liu, W., Wang, X., O'Connor, M., Wang, G., & Han, F. (2020). Brain-Derived Neurotrophic Factor and Its Potential Therapeutic Role in Stroke Comorbidities. *Neural plasticity*, *2020*, 1969482. https://doi.org/10.1155/2020/1969482

[6] Zhang, Z., Zhang, N., Ding, S. PhD (2022). Glial cell line-derived neurotrophic factor in brain repair after focal ischemic stroke, *Neural Regeneration Research,* 17 (8), p. 1735-1736. doi: 10.4103/1673-5374.332141

[7] Kleim, J.A., Jones, T.A. (2008). Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. *J Speech Lang Hear Res.* 51(1):S225-39. doi: 10.1044/1092-4388(2008/018).

[8]. Isobel, J. H., Mark, W. P., Cheryl Neilson, Leeanne M. Carey (2009). Task-specific training: evidence for and translation to clinical practice. Occup. Ther. Int.16(3 – 4):175 –189. Retrieved from https://onlinelibrary.wiley.com/doi/epdf/10.1002/oti.275

[9]. Grefkes, C., Fink, G.R. (2020). Recovery from stroke: current concepts and future perspectives. *Neurol. Res. Pract.* **2,** 17. https://doi.org/10.1186/s42466-020-00060-6

[10] Maier Martina, Ballester Belén Rubio, Verschure Paul F. M. J. (2019). Principles of Neurorehabilitation After Stroke Based on Motor Learning and Brain

Plasticity Mechanisms. *Frontiers in Systems Neuroscience, Vol 13, ISSN 1662-513, DOI=10.3389/fnsys.2019.00074*
[11]. Cramer S. C. (2018). Treatments to Promote Neural Repair after Stroke. *Journal of stroke*, *20*(1), 57–70. https://doi.org/10.5853/jos.2017.02796
[12]. Regenhardt, R. W., Takase, H., Lo, E. H., & Lin, D. J. (2020). Translating concepts of neural repair after stroke: Structural and functional targets for recovery. *Restorative neurology and neuroscience*, *38*(1), 67–92. https://doi.org/10.3233/RNN-190978
[13]. Ashley, M. J. (2012). Repairing the injured brain: why proper rehabilitation is essential to recovering function. *Cerebrum:the Dana forum on brain science*, 8. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3574768/