Stimulation of sensory receptors by dynamic muscle reproduction in patients with immediate post-stroke sequelae and proprioceptive neuromuscular facilitation: a systematic review

Estimulação de receptores sensoriais por reprodução dinâmica muscular em pacientes com sequelas imediatas de acidente vascular cerebral e facilitação neuromuscular proprioceptiva: uma revisão sistemática

Estimulación de receptores sensoriales mediante reproducción muscular dinámica en pacientes con secuelas inmediatas de accidente cerebrovascular y facilitación neuromuscular propioceptiva: una revisión sistemática.

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ABSTRACT
Objective: Review and synthesize the effectiveness of the dynamic muscle reprogramming/reeducation method with proprioceptive neuromuscular facilitation after stroke.
Method: This is a literature review carried out in the Pubmed, Scielo, Physiotherapy Evidence Database, Virtual Health Library, and Cochrane Library databases, between August 2021 and April 2022, including works that addressed PNF and the dynamic muscle reprogramming method.
Results: 286 articles were found in the different databases and analyzed in different stages, starting with the title and abstract. 1 selected from PubMed, 4 eligible and only 1 selected; only selected from Cochrane Library; and in PEDro only 1 included.
Conclusion: We did not achieve the aim of the study, however, we can elucidate that both methods promote effective stimulation of the somatosensory system. RDM stimulation is by voice command, without manipulation by the therapist, and micro-movements are made in the proprioceptive elements by the individual themselves to achieve the desired results.

Keywords: Stroke, sensation, proprioception, rehabilitation.

RESUMO
Objetivo: Revisar e sintetizar a eficácia do método de reprogramação muscular dinâmica com facilitação neuromuscular proprioceptiva após o acidente vascular cerebral. Método: Revisão da literatura realizada nas bases de dados PubMed, Scielo, Physiotherapy Evidence Database, Biblioteca Virtual em Saúde e Biblioteca Cochrane, entre agosto de 2021 e abril de 2022, incluindo trabalhos que abordassem FNP e o método de reprogramação muscular dinâmica.
Resultados: Foram encontrados 286 artigos e analisados em diferentes etapas, começando pelo título e resumo. Um foi selecionado do PubMed, 4 foram elegíveis e apenas 1 selecionado; apenas um foi selecionado da Biblioteca Cochrane; e no PEDro apenas 1 foi incluído.
Conclusão: Não alcançamos o objetivo do estudo, entretanto, podemos elucidar que ambos os métodos promovem uma estimulação eficaz do sistema somatosensorial. A estimulação no RDM é por voz, sem manipulação pelo terapeuta, e micro-movimentos são feitos nos elementos proprioceptivos pelo próprio indivíduo para alcançar os resultados.

Palavras-chave: AVC, sensação, propriocepção, reabilitação.

RESUMEN
Objetivo: Revisar la efectividad del método de reprogramación muscular dinámica con facilitación neuromuscular propioceptiva después de un accidente cerebrovascular. Método: Revisión de literatura realizada en las bases de datos de Pubmed, Scielo, Physiotherapy Evidence Database, Biblioteca Virtual en Salud y Biblioteca Cochrane, entre agosto de 2021 y abril de 2022, incluyendo trabajos que abordaran la FNP y el método de reprogramación muscular dinámica. Resultados: Se encontraron 286 artículos y se analizaron en diferentes etapas. Se seleccionó 1 de PubMed, 4 fueron elegibles y 1 seleccionado; se seleccionó 1 de la Biblioteca Cochrane; y en PEDro se incluyó 1. Conclusión: No logramos el objetivo del estudio, pero podemos elucidar que ambos os métodos promueven una estimulación efectiva del sistema somatosensorial. En el RDM, la estimulación se realiza mediante voz, sin manipulación por parte del terapeuta, y los micro-movimientos se realizan en los elementos proprioceptivos por el individuo para lograr los resultados.

Palabras clave: Accidente Cerebrovascular, sensación, propiocepción, rehabilitación.
1 INTRODUCTION

In 2013, stroke was the second most common cause of death worldwide and in Brazil, as of 2016, stroke became the second leading cause of death, behind acute myocardial infarction (AMI). In 2020, data from the Ministry of Health’s Mortality Information System (DATASUS) showed 99,010 deaths from stroke in Brazil (including data from cerebral infarction, ischemic stroke, hemorrhagic stroke, subarachnoid hemorrhage and stroke not specified as ischemic or hemorrhagic. (Feigin et al., 2021; DATASUS, 2020)

Recovery from neurophysiological changes after a stroke can vary. It usually starts within the first two weeks and can continue for years after the stroke, but at a slower rate over time. However, some factors such as age, existing comorbidities and participation in physiotherapy sessions can also affect the speed and quality of recovery, as their continuity reduces the precipitation of progressive worsening. (Nevis et al., 2020)

The pandemic has affected more than 210 countries, with more than 29 million confirmed cases, causing more than 900,000 deaths, as well as 15,433,989 recoveries. SARS-CoV2 is a disease marked by fever, dry cough, dyspnea and hypoxia, with characteristics of interstitial pneumonia, confirmed on chest X-rays or computerized imaging (Nannoni et al., 2021), interfering with post-stroke treatment.

Post-stroke sequelae are more susceptible to developing complications from SARS-CoV2 infection, which can lead to death, according to data published by Aggarwal et al. in the Journal of Stroke, which still needs to be determined, because it is suggested that SARS-CoV2 infection itself can cause stroke. (Aggarwal et al., 2020)

A study of 214 cases of SARS-CoV2 infection in Wuhan, China, where the pandemic was first identified, found that 36.4% of individuals had neurological symptoms, and these were more frequent in patients with severe disease (Aggarwal et al., 2020; Markus, 2020) and that post-stroke individuals should aim to perform moderate-intensity physical activity (aerobic exercise) for between 10 and 40 minutes, three to five days a week.

In this way, it is possible to determine various forms of physiotherapeutic rehabilitation after an immediate stroke and, among them, we highlight a new concept, which is Dynamic Muscle Reprogramming/Reeducation (RDM), which was developed by Dr. Francisco Miguel Pinto in the 1990s, and is carried out individually, using polymers, which are proprioceptive...
elements/EPCs of various sizes, shapes and colors with different intensities (green=strong; blue=moderate; yellow=soft), respecting each patient's body condition and does not cause injury. RDM can be worked on with children from the age of 7 to the elderly, in a progressive, continuous and evolutionary way towards bodily self-mastery, acting not only on the spine, but on the dynamics of other joints and muscles, through micro-movements performed on proprioceptive versus resistive elements. (Markus, 2020)

The main quality of RDM is rehabilitation through induced self-therapy, where the patient is taught point by point to know and recognize their alterations and limitations, as well as to rehabilitate the body's movements, restoring the entire posture, allowing blockages to be removed and every aspect of the postural reconstruction process to be controlled. The resources used in the application of MDR are diverse and make it possible to understand and carry out micro-movements at joint points, known as "body codes", in a facilitated way, throughout the rehabilitation process to unblock and rebalance tense and painful regions, which, through the central nervous system, are decoded with new movements for a global release of muscle tension (Pinto, 2019), promoting relaxation and strengthening of muscle groups in the various body areas to be rehabilitated. (Martini et al., 2018)

Proprioception depends on populations of mechanosensory neurons distributed throughout the body, which are collectively called proprioceptors. The movement and position of the body are reflected by the activity of different types of sensory neurons. Embedded deep in the skeletal muscles are muscle spindles: connective tissue capsules containing specialized intrafusal muscle fibers positioned parallel to the extrafusal muscle fibers innervated by alpha motor neurons. The projections of the primary sensory neurons, known as group Ia afferents, spiral around the central portion of the intrafusal fibers and respond to muscle stretch with short bursts of action potentials. Group Ia neurons encode both muscle length and the rate of change (speed) of muscle length. On the sides of the Ia fibers, at the edge of the spindle, are the sensory endings of the secondary or group II afferents, which linearly encode static muscle length. A potential advantage of velocity sensitivity in Ia afferents is the rapid detection of postural disturbances (before major changes in position magnitude occur and are detected by group II afferents). (Tuthil and Azim, 2018)

However, we can point to another physiotherapeutic resource, known by professionals in the field, which is Proprioceptive Neuromuscular Facilitation (PNF). PNF is applied in different
areas of physiotherapists' specialization, especially in neurological physiotherapy, a method recognized and used in several countries. (Lacerda et al., 2013)

This method was developed in 1940 by Dr. Herman Kabat and Margareth Knott, when they decided to apply it to treat patients with poliomyelitis, accentuating functional movement by facilitating, inhibiting, strengthening and relaxing muscle groups. (Santos et al., 2020; Gunning and Uszynski, 2019)

FNP is a technique based on a philosophy that views the human being as a whole. From this, FNP aims to provide a positive, motivating and encouraging treatment for patients, where they can reach their potential, stimulating physical and psychological rehabilitation. (Souza et al., 2020)

This therapeutic resource involves treatment at different levels: body structure, activity and participation with a positive approach, which means using activities that the patient can already do. Thus, the functional approach is the most effective way of stimulating the patient and achieving the best therapeutic results. (Maicki et al., 2017)

Both techniques use proprioception as their main point, unlike FNP, in RDM the therapist does not have direct contact with the patient at the time of therapy, it is self-therapy which requires greater concentration and mastery, so it is essential to compare the two techniques in post-stroke rehabilitation.

Therefore, the aim of the study is to review and synthesize the effectiveness of the dynamic muscle reprogramming/reeducation method with the proprioceptive neuromuscular facilitation method after stroke.

2 METHODOLOGY

This is a literature review in which relevant searches were conducted in the databases PubMed, Scielo, Physiotherapy Evidence Database (PEDro), Virtual Health Library (BVS), and Cochrane Library.

The research was conducted from August 2021 to April 2022. Original articles published between 2018 and 2022, in Portuguese and English, were included if obtained in full and addressing the theme of proprioceptive neuromuscular facilitation. In this review, the selected articles were all randomized controlled trials and observational studies.
Articles addressing physiotherapeutic rehabilitation through PNF (Proprioceptive Neuromuscular Facilitation) and the concept of Dynamic Muscle Reprogramming/Reeducation (RDM) were included. Excluded were articles that were not available in full, whose main objective was not to evaluate PNF, such as rehabilitation, as well as articles involving surgical techniques or invasive methods for comparison.

The search strategy for potential studies varied according to the search system of each database. The search was conducted using appropriate descriptors and/or keywords with the following descriptors: stroke and covid, stroke and physiotherapy, Muscle Stretching Exercises and stroke, PNF and stroke, Cellular Reprogramming Techniques. Literature was searched comprehensively using different combinations of these terms. After searching for potential studies in the databases, the abstracts of all articles were analyzed by two independent evaluators, who provided their opinion on whether or not to include the articles in the review.

This study used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) items guidelines (Page et al., 2022). To assess the quality of studies that met the inclusion criteria, the Pedro scale was used. The interpretation of the scores, which evaluates the quality of articles as high (6 to 10 points), fair (4 to 5 points), and poor (3 or lower), was used. The scale is considered a valid measure of the methodological quality of clinical trials and has reliability levels from fair to good for classifying the quality of systematic reviews.

3 RESULTS AND DISCUSSIONS

A total of 286 articles were found in different databases, articles on PNF and RDM, conducted in men and women aged 18 and over, and analyzed at different stages. Initially, they were reviewed by title and abstract: out of the 56 found in PubMed, 4 were eligible and only 1 was selected; in the Cochrane Library, out of 13 articles, only 1 was selected; and in PEDro, out of 9 articles found, only 1 was included, while no articles were included in BVS due to duplicity. These details are represented in the flowchart 1, presented below.
Flowchart: Flowchart of the study selection process for the systematic review

Records identified during the search in the databases: PubMed (n=56), Cochrane Library (n=74), PEDro (n=53), BVS (n=123), TOTAL 286

Filters: English, at least 5 years ago, systematic review, randomized and observational studies.

45 articles were selected for this study.

10 excluded due to unauthorized access, 13 duplicates, and 19 excluded after full-text reading.

At the end, 3 articles were included in this review.

Source: own author (2022)

It can be observed in Table 1 that all articles using PNF showed significant improvement in different aspects, including upper limb functions, gait alterations, and balance. Most studies used all segments of PNF involving autogenic inhibition, reciprocal inhibition, diagonal patterns, rhythmic stabilization, repeated contraction, antagonist contraction, slow reversal, functional stretch reflex, maintaining relaxation, reflex excitability, contract and relax. In all studies, the physiotherapist had to be trained in the technique to apply it to patients.

Table 1: Characteristics of systematically selected studies

<table>
<thead>
<tr>
<th>Author, year and Study type</th>
<th>Objective</th>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARK, 2020 Effect of diagonal pattern training on trunk, balance, and gait in stroke patients: A randomized controlled clinical trial.</td>
<td>&quot;To investigate the effect of diagonal pattern training in the seated position on improving trunk control in balance and gait in stroke patients.&quot;</td>
<td>To be diagnosed with stroke on MRI for more than 6 months; aged between 45 and 70 years; have a Mini-Mental State Examination-Korean (MMSE-K) score of 24 or higher; elbow flexor Ashworth Scale score of 1 or +1; consent to participate in the study after receiving a</td>
<td>Changes in gait and balance were observed in stroke patients. The results indicate that diagonal pattern training may be considered a potential method to improve postural control, increase balance, and improve gait in stroke.</td>
</tr>
</tbody>
</table>
In the study by Park and Seunghue 2020, 42 people participated, with 21 in the control group and 21 in the experimental group. The diagonal pattern training was modified with the cutting pattern and lifting of the proprioceptive pattern of PNF, to create 10 movements. All movements were performed in the sitting position on an adjustable height mat with crossed fingers to perform the movements on the paralyzed hand. The experimental group underwent 20 sessions of diagonal pattern training over 4 weeks; the control group underwent single-plane training 20 times over 4 weeks, and except for this training, general treatment was allowed in both groups. In addition, evaluation was performed before and 4 weeks after the intervention. In this study, 2 patients were discharged from the experimental group, 1 patient was discharged from the control group, and 1 patient was removed during the intervention (Park and Seunghue, 2020).

In the study by Junior et al. 2019, 48 participants were recruited and randomly allocated to 3 groups: PNF, VR (virtual reality), and PNF/VR, with interventions conducted twice a week
for 50 minutes, with all groups starting therapy with 10 minutes of upper and lower limb stretching. The PNF sequence included scapula, upper limb, pelvis, lower limb, and gait training, distributed over two weekly sessions. Training was conducted in different positions (supine, sitting, standing), according to the specific exercise. In the VR group, tasks were performed using a Nintendo Wii device, in a 20m2 room equipped with a multimedia projector, and games included multidirectional displacement exercises, stationary gait, and upper limb exercises (Junior et al., 2019).

Kim and Kim 2018 used 23 patients in his study, 11 in the control group receiving treadmill training only and an experimental group (n=12) receiving combined training. In this study, 40-minute training programs for both groups were conducted five times a week for six weeks, with 5 minutes allocated to warm-up, 30 minutes to the main exercise, and 5 minutes to cool down. Both PNF exercise and treadmill were implemented in the combined training program. In the PNF concept, therapists performed diametrical scapular and pelvic movement patterns using basic physiotherapy principles, procedures, and techniques, with combined training consisting of warm-up, PNF, treadmill, and cooldown.

The three articles included in the study were randomized clinical trials, with scores on the Pedro scale ranging from 7 to 10, as shown in the table below, with a median of 8 points. The table below presents the scores of methodological qualities of the selected studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>PARK, 2020</th>
<th>JUNIOR, 2019</th>
<th>KIM, 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligibility criteria</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Random allocation</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Similar baseline groups</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Subject blindness</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Therapist blindness</td>
<td>S</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Evaluator blindness</td>
<td>S</td>
<td>S</td>
<td>N</td>
</tr>
<tr>
<td>Main results</td>
<td>S</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>All subjects received</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Between-group</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Statistics</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Point estimate and variability</td>
<td>S</td>
<td>N</td>
<td>S</td>
</tr>
<tr>
<td>Total score</td>
<td>10</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: own author (2022)

This study aimed to review and synthesize the efficacy of dynamic muscle reprogramming/reeducation method with the proprioceptive neuromuscular facilitation method.
post-stroke. However, it was not possible to achieve the objective, as RDM is new and there are few published studies on the subject, especially regarding articles on proprioception.

Thus, this is the first article that shows the approach of RDM in post-stroke sequelae. Therefore, the discussion will focus on techniques similar to RDM that use proprioception as a form of rehabilitation.

Consequently, we clarify the existence of only four articles that used RDM in clinical practice, addressing topics such as low back pain in industrial workers, postural balance, spinal cord injury, and traumatic brain injury.

Brain injuries post-stroke cause damage and death to neuron cells, resulting in deficits in motor and cognitive function, leading to loss of functional performance capacity, such as post-stroke hemiparesis, where the patient cannot move injured body segments, hindering daily activities. However, if the patient undergoes physiotherapy sessions, the nervous system may have the ability to reconnect to other areas, promoting neuroplasticity, thus improving functionality. Neuroplasticity is precisely the brain's ability to rebuild its network of neurons in the healthy part of the brain to assume the role of the damaged part (Rahayu et al., 2020).

The neurological motor learning involves the modification of motor responses by the nervous system, where the patient is encouraged to activate the cognitive process. This is an intrinsic process that occurs gradually and requires constant repetitions, due to the changes that have occurred in their tissue during development and maturation (Kim and Jang, 2021).

PNF produces greater adaptive plasticity as neural recruitment increases. The technique uses the body's proprioceptive system to facilitate or inhibit muscle contraction (Kim and Jang, 2021), similar to RDM, which relies on proprioceptive elements (EPCs) inserted at strategic points to enable stretching, relaxation, and strengthening of muscle groups through micro movements performed by the individual, which we can call self-induced therapy. While in PNF, pressure is applied through manual contact, stimulating cutaneous and pressure receptors, informing the patient of the correct movement direction and increasing their ability to contract (Tula et al., 2017; Abreu et al., 2018).

Therefore, we can determine that the main difference between the two is that in RDM, the level of proprioception is higher compared to PNF because the patient needs to focus more attention, concentrate, and memorize the micro movements that are being or will be performed, as it is a self-therapy.
Delgado et al. concluded in his study that the results obtained in the treatment of a patient after traumatic brain injury affirm that RDM provided multidimensional rehabilitation, precisely due to all the behavioral changes that occurred in the patient, aided by microflexion exercises (Delgado et al., 2023).

Martini et al. conducted a study using RDM in spinal cord injury patients, observing changes in patient posture and indicating a decrease in scoliosis, increased range of motion in the cervical region, as well as changes in daily activities, such as drinking water, assisting with dressing, among other actions (Martini et al., 2018).

4 CONCLUSION

In this study, it is noted that it was not possible to achieve it due to the absence of articles addressing interventions with post-stroke individuals using the RDM concept.

Both concepts promote effective stimulation in the somatosensory system through stimuli in body segments. However, in PNF, this stimulation is necessary through verbal commands and manipulation of segments by the therapist, while in RDM, stimulation is through voice command, explaining movements according to the patient's assessment, without therapist manipulation, and micro movements are performed by the individual, allowing the reacquisition of sensorimotor perceptions, promoting movement control.

However, it should be noted that more studies with a larger number of individuals involved are needed.
REFERENCES


