Middle East Research Journal of Medical Sciences
ISSN: 2789-7699 (Print) & ISSN: 2958-2024 (Online)
Frequency: Bi-Monthly
DOI: https://doi.org/10.36348/merjms.2025.v05i03.002

KUWAIT SCHOLARS PUBLISHER
Website: http://www.kspublisher.com/
Email: office@kspublisher.com

Study Neuromodulation in People Who Practice Physical Activity, Assist in the Evaluation of Athletes, the Benefits of Jiu Jitsu Neuroplasticity for the Autistic Brain, and Muscle Memory

Marco Vinícios de Oliveira Santana[1], Carlos Henrique Marchiori[1*], Klebert de Paula Malheiros[1], Fernando Marques Faustino[1]
[1]Researchers of Instituto Marco Santana, Goiânia, Goiás, Brazil

Abstract: Neuromodulation can enhance neuroplasticity, which improves. For example, it can be used to treat disorders such as depression, schizophrenia, and Parkinson's disease, or to restore motor, cognitive, or speech functions. Physical activity offers multiple health benefits for everyone, at any age, and for both women and men. Neuromodulation for those suffering from muscle overload, including: Pain reduction, improved neuromotor control, increased muscle performance, and accelerated rehabilitation, children with autism, developing social skills, improving motor coordination, and increasing confidence. Practicing Jiu-Jitsu promotes neuroplasticity, the brain's ability to adapt and form new neural connections. This can be especially beneficial for children with autism, as Jiu-Jitsu helps strengthen areas of the brain that may be less developed. Neuromuscular memory refers to the body's ability to recover strength and muscle mass more quickly after a period of inactivity, due to adaptations in the nervous system and muscles. The objective of the manuscript is to understand how neuromodulation occurs for people who perform physical activity, to help in the evaluation of athletes, the neuroplasticity benefits of Jiu Jitsu for the autistic brain and muscle memory. This work is a literature review, based on scientific articles. The inclusion criteria for the articles that were part of this review were: articles published in the last 15 years and published in Portuguese and English on the subject, carefully selected from databases such as Scielo, PubMed, Google Scholar, Capes Portal, Latin American and Caribbean Literature in Health Sciences, Scielo, SSRN and ResearchGate using the following criteria keyword: neuromodulation, neuroplasticity, neuromuscular memory, port, physical activity.

Keywords: Benefits, Disorder, Health, Muscles, Nervous System, Tool.

Research Paper

***Corresponding Author:**
Carlos Henrique Marchiori
Researcher of Instituto Marco Santana, Goiânia, Goiás, Brazil

How to cite this paper:
Marco Vinícios de Oliveira Santana *et al* (2025). Study Neuromodulation in People who Practice Physical Activity, Assist in the Evaluation of Athletes, the Benefits of Jiu Jitsu Neuroplasticity for the Autistic Brain, and Muscle Memory. *Middle East Res J. Med. Sci*, *5*(3): 239-258.

Article History:
| Submit: 08.04.2025 |
| Accepted: 07.05.2025 |
| Published: 15.05.2025 |

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1.0. INTRODUCTION

The Central Nervous System (CNS) is part of the nervous system responsible for receiving, processing, and integrating information, and sending commands to the body. It consists of the brain, cerebellum, brain stem, diencephalon, and the spinal cord. The brain, located in the skull, generates commands, while the spinal cord, inside the vertebral column, connects the brain to the peripheral organs and tissues (Figure 1) (Junqueira and Carneiro, 2008; Machado, 2022).

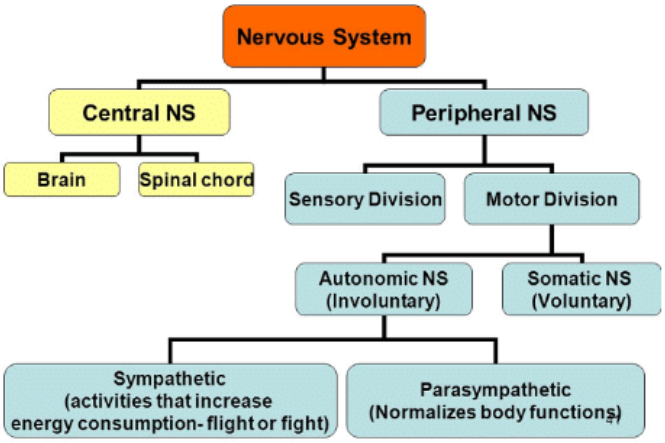

Figure 1: Central Nervous System (CNS)
Source: https://edurev.in/t/91791/The-Central-Nervous-System-and-Human-Brain

The spinal cord is located inside the vertebral canal, extending from the foramen magnum to the first or second lumbar vertebrae level. Its anatomy reflects its function: conducting nerve impulses between the brain and the other, making the reflex arcs viable. This is the place where the bodies of the neurons are located and where the information is processed (Kandel *et al.*, 2001; Tortora and Derrickson, 2013; Carlson, 2014).

It is configured in different ways: ventral, dorsal, lateral, and intermediate. Dorsal horn: responsible for sensory information. intermediate: the place where we find the interneurons that link one neuron to another, the association neuron. Lateral horn: found just below the thoracic and lumbar levels. It is responsible for regulating the autonomic nervous system. Ventral horn: responsible for motor information (Kandell *et al.*, 2001; Tortora and Derrickson, 2013; Carlson, 2014).

Ventral horn: responsible for motor information. Dorsal horn: responsible for sensory information. These connect neurons and are association neurons. Lateral horn: found only at the thoracic and lumbar levels. It is responsible for the body's homeostasis, regulating the autonomic nervous system (Figure 2) (Kandell *et al.*, 2001; Tortora and Derrickson, 2013; Carlson, 2014).

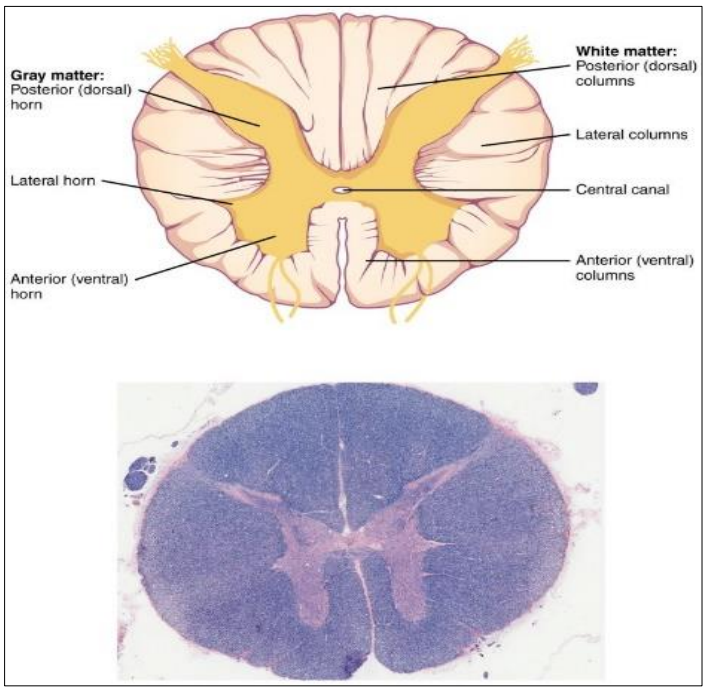

Figure 2: The cross-section of a thoracic spinal cord segment shows the posterior, anterior, and lateral horns of gray matter, as well as the posterior, anterior, and lateral columns of white matter

Sources: Human Physiology: The Central Nervous System, Summer Ekelund, archive.cnx.org, and https://www.pinterest.com/pin/ou-human-physiology-the-central-nervous-system--369928556873630616/

1.1. OBJECTIVE

The objective of the manuscript is to understand how neuromodulation occurs in people who perform physical activity, to help in the evaluation of athletes, and to discuss the neuroplasticity benefits of Jiu Jitsu for the autistic brain and muscle memory.

2.0. METHODS

This work is a literature review, based on scientific articles. The inclusion criteria for the articles that were part of this review were: articles published in the last 15 years and published in Portuguese and English on the subject, carefully selected from databases such as Scielo, PubMed, Google Scholar, Capes Portal, Latin American and Caribbean Literature in Health Sciences, Scielo, SSRN and ResearchGate using the following criteria.

3.0. SELECTED STUDIES

3.1. Neuromodulation

Neuromodulation can enhance neuroplasticity, which improves. For example, it can be used to treat disorders such as depression, schizophrenia, and Parkinson's disease, or to restore motor, cognitive, or speech functions. To encourage neuroplasticity, you can do activities that challenge the brain, such as learning a new language or playing a musical instrument (Krakauer *et al.*, 2012; Lefaucheur *et al.*, 2020; Makowski, 2020).

Neuromodulation can be beneficial for people who practice physical activities, especially those who do not control their sleep, in rehabilitating injuries, and improving muscle function. This technique uses controlled electrical impulses to influence the activity of the nervous system, improving communication between the brain and the muscles (Lefaucheur *et al.*, 2020; Makowski, 2020).

Percutaneous Neuromodulation (PNM) is an invasive technique whose objective is to intervene in the Central Nervous System (CNS) and Peripheral Nervous System (PNS). Percutaneous neuromodulation, constituted by the dorsal horn of the spinal cord, is stimulated by various nerve branches at the peripheral level, both sensory and motor, inhibiting the conduction of hyperactive nerves employing pulses (Figure 3) (Lefaucheur *et al.*, 2020; Makowski, 2020; Fernández, 2021; San-Emeterio-Iglesias *et al.*, 2022).

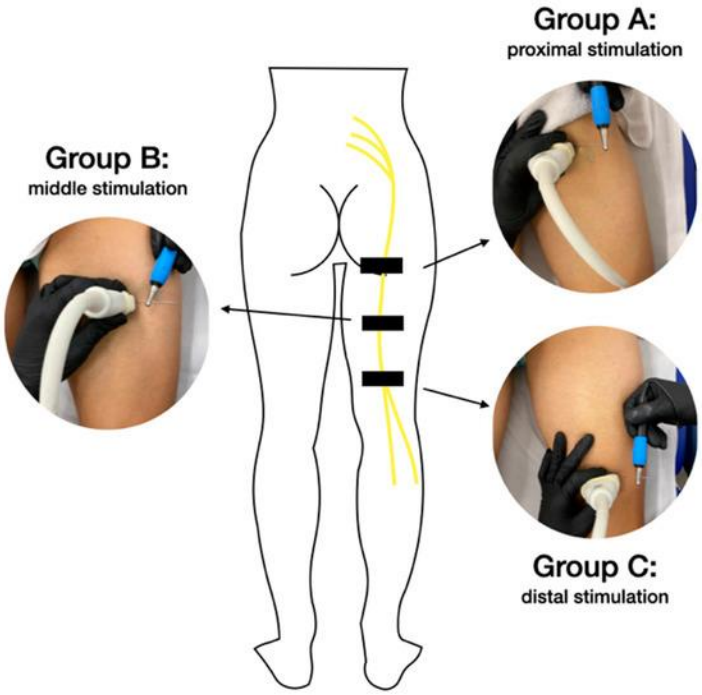

Figure 3: Ultrasound-guided percutaneous neuromodulation. Proximal stimulation of the sciatic nerve (Group A); sciatic nerve stimulation in the middle of the thigh (Group B); distal stimulation of the sciatic nerve (Group C)
Source: https://doi.org/10.3390/jcm11226672

These pulses generated by the device excite two peripheral nerves using electrical impulses. The nerve's electrochemical environment is modified to depolarize, initiating an analgesic and restorative response, processes mediated by the immune and endocrine

systems (Fernandes *et al.*, 2020; Lefaucheur *et al.*, 2020; Fernández, 2021).

3.1.1. Benefits of neuromodulation for physically active people:

1. Dormancy: Neuromodulation can help alleviate chronic pain, common in people who practice physical activities, especially those with musculoskeletal injuries.
2. Injury Rehabilitation: Neuromodulation can facilitate injury recovery, improving muscle function and sleep tolerance during rehabilitation.
3. Improved muscle function: Neuromodulation can help improve muscle function, which is especially important for athletes and people who participate in high-performance sports. (Bayona *et al.*, 2011; Bucher and Marder, 2013; Casal-Beloy *et al.*, 2020).
4. Correction of movement patterns: Neuromodulation can help correct altered movement patterns. and is useful in the rehabilitation of injuries and the improvement of athletic performance.
5. Physical activity improves cognitive function, memory, efficiency, and attention, and also prevents cognitive decline.
6. It increases serotonin levels, reducing anxiety and depression. It improves body image, self-control, and sexual satisfaction.
7. Prevention of injuries: By helping to improve muscle function and communication between the brain and muscles, neuromodulation can help prevent injuries. Reduced stress and anxiety: Neuromodulation can help 6. reduce stress and anxiety, which can affect performance and recovery (Bayona *et al.*, 2011; Bucher, 2013; Casal-Beloy *et al.*, 2020).

3.1.2. Types of neuromodulations:

1. Percutaneous Neuromodulation (PNM) is an invasive technique whose objective is to intervene in the central nervous system (CNS) and peripheral nervous system (PNS). In the hands of a physiotherapist, it is a completely safe, effective, and painless technique (Bayona *et al.*, 2011; Bucher, 2013; Casal-Beloy *et al.*, 2020).
2. Transcranial Stimulation by Continuous Current (ETCC): This technique uses weak electrical currents to stimulate the cerebral cortex (Bayona *et al.*, 2011; Bucher, 2013).
3. Transcranial Magnetic Stimulation (TMS): This technique uses magnetic fields to stimulate the cerebral cortex (Bucher, 2013; Casal-Beloy *et al.*, 2020).
4. Percutaneous Neuromodulation (PNM): A percutaneous neuromodulation, constituted by a dorsal horn of the spinal cord, is stimulated by various nerve branches at the peripheral level, both sensory and motor, inhibiting the conduction of hyperactive nerves employing pulses. These pulses generated by the device excite two peripheral nerves employing electrical impulses. The electrobiochemical environment of the nerve is being modified to depolarize, initiating analgesic and reparative responses, processes that are mediated by the immune and endocrine systems (Casal-Beloy *et al.*, 2020; Fernandes *et al.*, 2020; Lefaucheur *et al.*, 2020; Makowski, 2020; Fernández, 2021).
5. Non-invasive neuromodulation NESA (Casal-Beloy *et al.*, 2020; Fernandes *et al.*, 2020; Lefaucheur *et al.*, 2020; Makowski, 2020; Fernández, 2021).

The effectiveness of neuromodulation may vary depending on the type of technique used and the patient's condition. In general, neuromodulation is a useful tool for people who practice physical activity because it can help improve muscle function, relieve pain, facilitate injury rehabilitation, and prevent future injuries (Casal-Beloy *et al.*, 2020; Fernandes *et al.*, 2020; Fernández, 2021).

3.1.3. Benefits of neuromodulation in the treatment of chronic pain

Chronic pain can be debilitating and significantly affect patients' quality of life. Below, we explore how neuromodulation offers a viable solution:

1. Drug-free pain relief.
2. Reduction of inflammation and muscle tension.
3. Improved mood and quality of life (Figure 4) (Cruccu *et al.*, 2007).

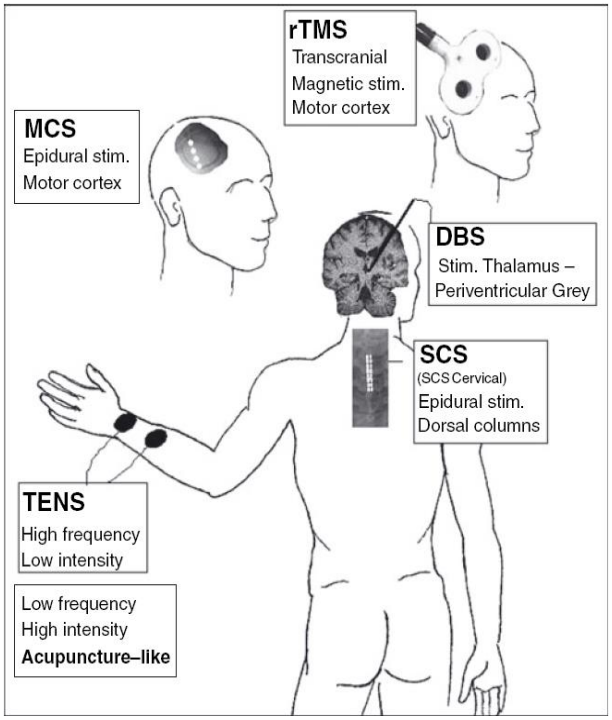

Figure 4: Schematic representation of different neurostimulation procedures, e.g., for a patient with pain in the left hand because of peripheral nerve injury

Source: Doi: 10.1111/j.1468-1331.2007.01916.x.

Neuromodulation allows our patients to achieve these benefits, either in combination with other advanced techniques, such as ultrasound-guided dry needling, or as a primary treatment, and is effective for a variety of conditions, ranging from neuropathic pain to chronic musculoskeletal disorders. Some of the most commonly treated conditions include:

1. Sciatica pain.
2. Fibromyalgia.
3. Neuropathies.
4. Carpal tunnel injuries.

Scientific evidence supports the use of neuromodulation in pain treatment. According to recent studies, neuromodulation has shown an effectiveness of over 70% in reducing chronic pain in patients who have not responded to other treatments (Fernandes *et al.*, 2020; Fernández, 2021).

3.2. Neuroplasticity

Neuroplasticity, one of the most revolutionary concepts in neuroscience, refers to the brain's marvelous ability to adapt and transform. This capacity is vital in neurorehabilitation, helping people recover from brain injuries and disorders. In recent years, neuromodulation has emerged as a promising technique to enhance this plasticity (Figure 5) (Dobkin, 2003; Krakauer *et al.*, 2012; Laver *et al.*, 2017; García, 2022).

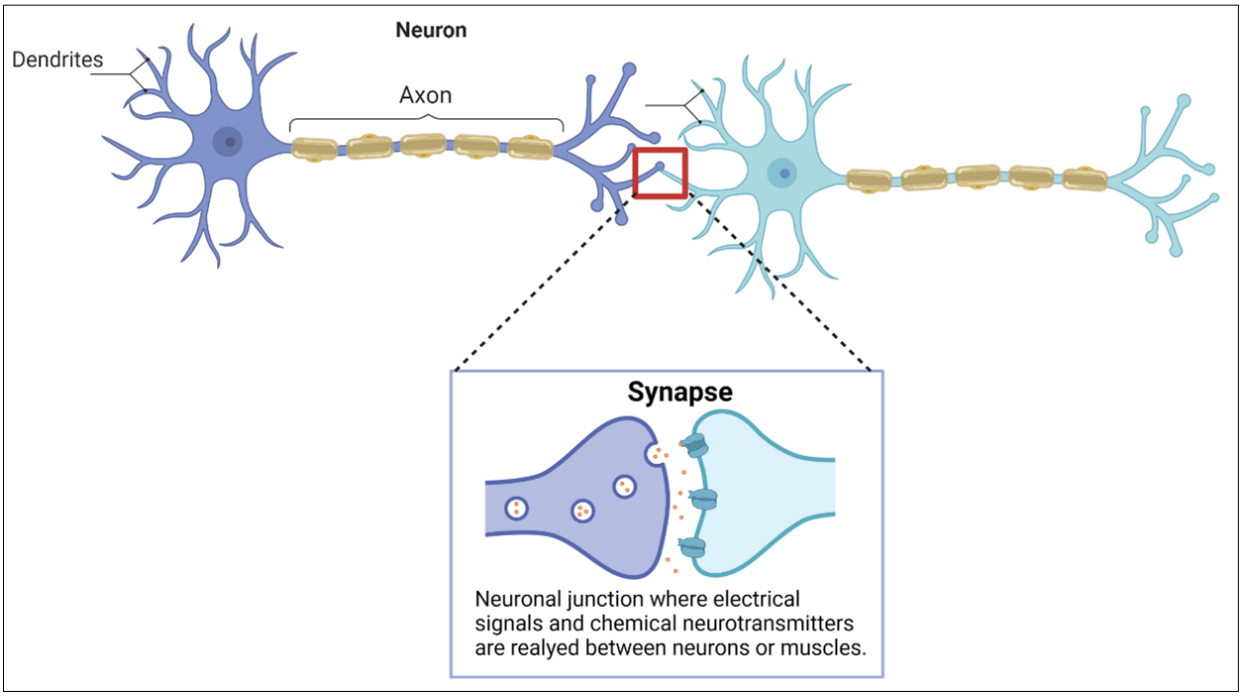

Figure 5: Neuroplasticity - Structure of a neuron and synapses -

Sources: Image created with Biorender.com, by Lalitha Ramasubramanian/ December 09, 2022, and https://biotech.ucdavis.edu/blog/neuroplasticity

Neuroplasticity is the brain's incredible power to change and adapt throughout our lives. It is not a static capacity, but a dynamic one, and it comes in various forms: it can be the result of learning, experience, or recovery from brain injury. Neuroplasticity allows the brain to form new connections between neurons, allowing us to learn new skills, remember experiences, and adapt to new environments or situations (Krakauer *et al.,* 2012; García, 2022).

3.2.1. Neuromodulation/Neuroplasticity/Benefits for psychological and emotional well-being

Neuromodulation is effective for a variety of neuropsychological conditions. Its benefits include:

1. Reduction of symptoms of anxiety and depression.
2. Improvements in attention, memory, and cognitive processing.
3. Emotional regulation and increased subjective well-being (Figure 1) (Asp *et al.,* 2023; CP, 2025).

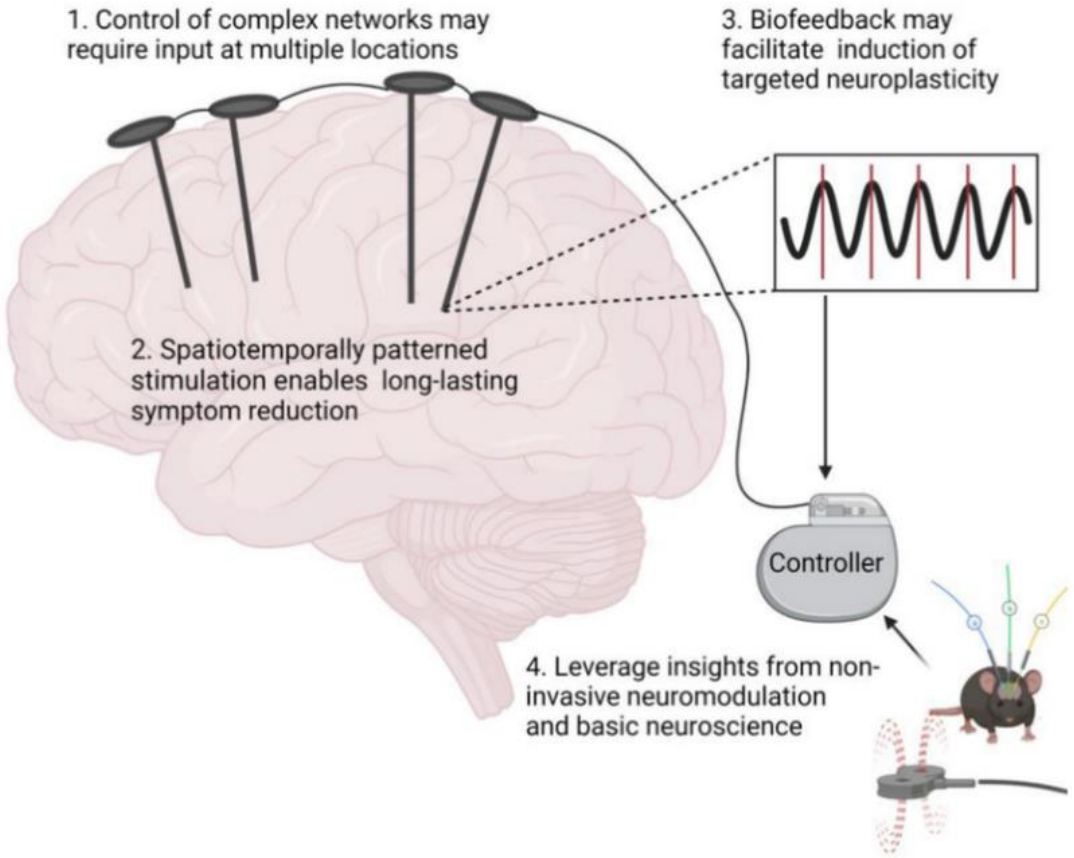

Figure 6: Targeted neuroplasticity approaches for invasive neuromodulation therapies
Sources: Figure created with Biorender.com and Doi: 10.3389/fninf.2023.1150157

These effects are achieved without the need for invasive or pharmacological interventions, minimizing side effects and facilitating treatment adherence (Krakauer *et al.,* 2012; García, 2022).

3.3. Physical activity

Physical activity is defined as any bodily movement produced by muscles that requires greater energy expenditure than at rest. Physical activity offers multiple health benefits for everyone, at any age, and for both women and men. The development of technology has made many tasks that previously required greater effort easier; we travel more by car or other motorized means and walk less (Catunda and Marques, 2017; Nahas, 2017).

Today, many jobs don't require much physical effort, and more and more leisure activities don't require movement. All of this is significantly influencing the increase in the number of people with health problems such as diabetes, cardiovascular disease, and cancer. Physical exercise is a specific type of physical activity that corresponds to a planned, structured, and repetitive body movement, and is carried out with an objective related to the improvement or maintenance of one or more components of physical fitness or physical condition (Débora *et al.,* 2015; Ferreira *et al.,* 2015).

Physical activity includes not only physical exercises, but also other activities that require physical

movement, such as active jumping, laser jumping, walking, dancing, cycling, and sports. In turn, it can be carried out in different environments, such as free time, at school, at work, at home, as part of daily activities and to move from one place to another, known as active mobility (Figure 7) (Débora *et al.*, 2015; Ferreira *et al.*, 2015; Catunda and Marques, 2017; Nahas, 2017).

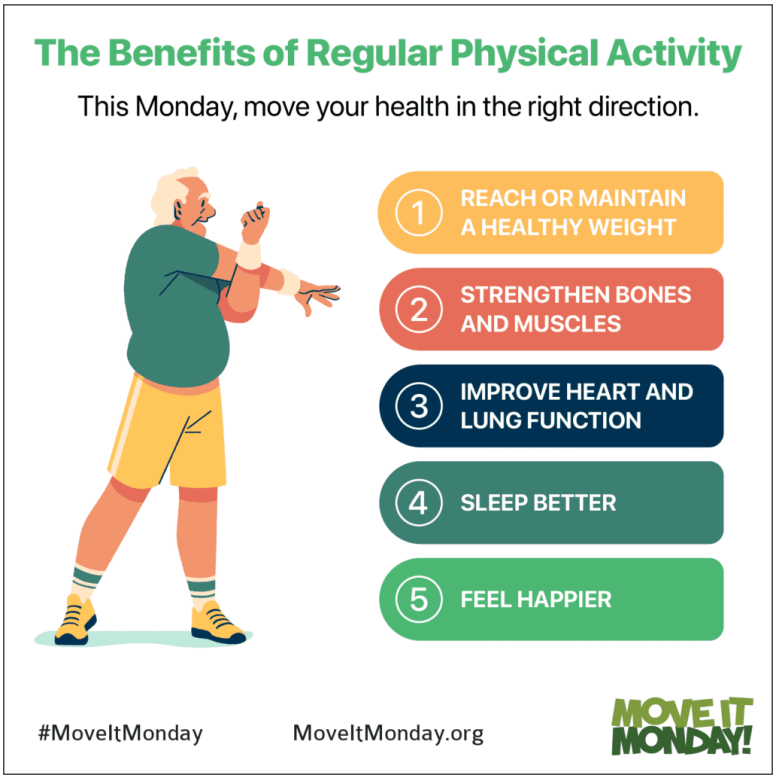

Figure 7: Regardless of your age or ability level, getting active, whether it's walking, jogging, strolling, rolling, stretching, yoga, dancing, or weightlifting, can positively impact your physical and mental wellbeing and lead to a better quality of life

Sources: ©2025 Syracuse University and ttps://healthymonday.com/physical-activity/the-many-benefits-of-regular-physical-activity

Physical activity has important benefits for physical and mental health. Currently, anxiety and depression are the most prevalent mental disorders in the world's population. However, epidemiological studies have observed that physical exercise helps reduce these disorders, in addition to being a good complementary therapy for treating addictive behaviors and reducing appetite and satiety cravings. Physical activity prevents age-related cognitive decline in healthy people, reduces the risk of developing dementia, and can improve quality of life in people with dementia, beyond the physical benefits it also brings (Débora *et al.*, 2015; Ferreira *et al.*, 2015; Catunda and Marques, 2017; Nahas, 2017).

3.3.1. Neuromodulation for people who engage in physical activity

Neuromodulation offers specific benefits for those suffering from muscle overload, including:

1. Pain reduction: It influences the nerve signals that send pain messages to the brain, thus reducing the feeling of discomfort.
2. Improved neuromotor control: It optimizes mobility and improves muscle contraction, helping to relieve chronic fatigue and feelings of heaviness.
3. Increased muscle performance: It contributes to muscle strength and endurance, promoting both recovery and preventing future injuries.
4. Accelerated rehabilitation: It stimulates neuronal plasticity, which facilitates faster and more efficient recovery (Deer *et al.*, 2014; Mahalakshmi *et al.*, 2020; CP, 2025).

3.3.2. Common types of muscle overload

Muscle overloads vary depending on their cause and location. Here are the most common ones:

1. Muscle contractures: Prolonged pain and stiffness that limit movement.
2. Tendinitis: Inflammation of the tendons, such as Achilles tendonitis or tennis elbow.
3. Delayed Onset Muscle Soreness (DOMS): A feeling of muscle ache after intense activity.

4. Fatigue Disorders: Pain and stiffness that worsen with repetitive exercise.
5. Stress Fractures: Cracks in the bones due to repetitive stress (Figure 8) (Deer *et al.*, 2014; Mahalakshmi *et al.*, 2020).

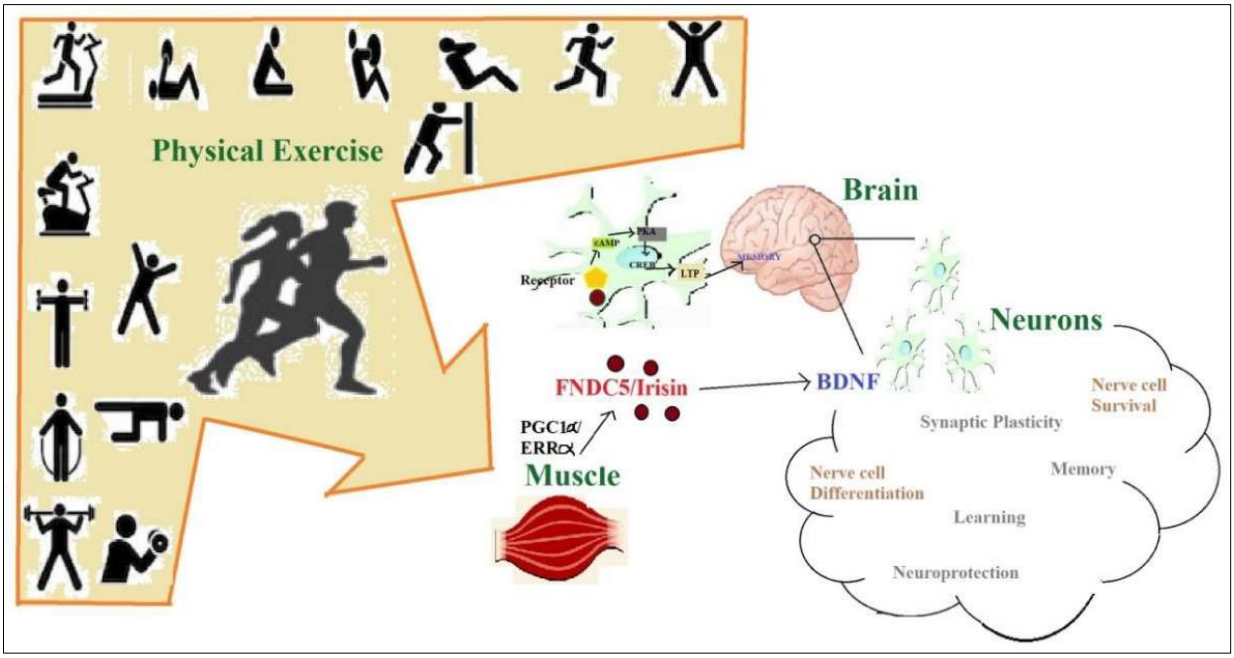

Figure 8: Effect of physical exercise (PE) on neurons involving brain-derived neurotrophic factors BDNF and irisin
Source: Doi: https://doi.org/10.3390/ijms21165895

Neuromodulation also has applications in treating chronic pain, in the rehabilitation of muscle and joint injuries, and in the correction of altered movement patterns. In high-performance sports, this technique represents an advanced and safe way to promote recovery and minimize the risk of relapses. It stimulates cellular regeneration processes and reduces inflammation in the affected area (Grigsby *et al.*, 2010; McRoberts *et al.*, 2013; Bill *et al.*, 2017).

Electrical impulses can increase the production of endorphins, which act as natural painkillers and help reduce pain, allowing the athlete to recover more tolerably. It reduces pain signals that may persist after an injury, helping to prevent the development of chronic pain patterns. This allows the athletes to continue their rehabilitation without significant restrictions and with better control over the pain they feel. With neuromuscular reprogramming, the athlete can avoid incorrect postures or misaligned movements that can re-injure the already injured area (Grigsby *et al.*, 2010; McRoberts *et al.*, 2013; Bill *et al.*, 2017).

3.3.3. Neuromodulation technique approach for low back pain

Percutaneous neuromodulation therapy is designed to treat patients with low back pain in the physical therapy office. A typical session involves applying up to 10 percutaneous neuromodulation electrodes, called safety leads, to the lower back and gluteal area in specific locations (McRoberts *et al.*, 2013; Clinic Barcelona, 2025).

Each safety lead deploys a fine-gauge filament electrode to a depth of three centimeters. For most patients, this insertion causes little to no discomfort. After deploying the electrodes, the physical therapist adjusts the electrical stimulation to a level that provides therapeutic benefits with minimal discomfort. The stimulation typically produces a tingling or deep tapping sensation in the area surrounding the electrodes. There are no activity restrictions for patients after the procedure (Figure 9) (McRoberts *et al.*, 2013; CAP, 2024; CP, 2024; Clinic Barcelona, 2025).

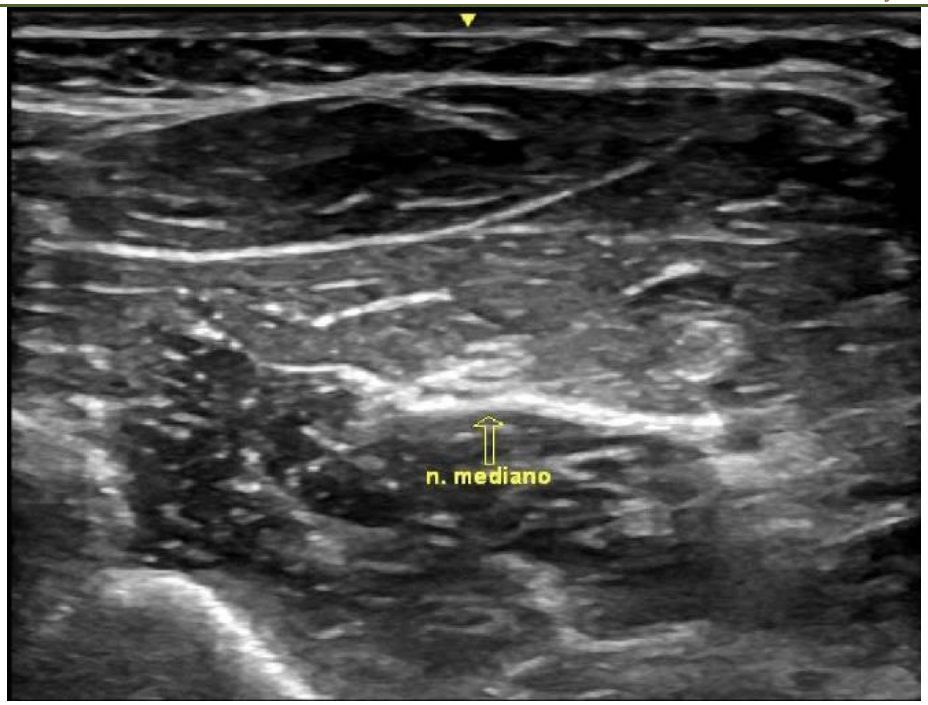

Figure 9: Use of ultrasound to locate the median nerve for the application of the percutaneous neuromodulation intervention

Sources: Doi:10.2147/DNND.S395082 and Corpus ID: 256345675

Patients are generally advised to commit to a course of three to four sessions before evaluating the procedure's effectiveness, as multiple sessions are typically required before a measurable benefit can be experienced. Patients with complex spinal pathologies are often best served through an integrated pain management approach. Therefore, patients may undergo this and other techniques in combination as part of a multidisciplinary treatment plan for low back pain (McRoberts *et al.,* 2013; CP, 2024; Clinic Barcelona, 2025).

3.3.4. Neuromodulation for chronic pain relief

Chronic pain has a major impact on daily life. It not only affects the physical but also impacts the emotional and social well-being of patients. Daily activities such as walking, working, or even sleeping can be profoundly altered. Neuromodulation offers a way to recover this lost functionality (MFAP, 2022).

Unlike pharmacological options, neuromodulation has the advantage of not relying on drugs and, therefore, avoiding the typical long-term side effects of medications, such as stomach upset or dependence. One of the main benefits of neuromodulation is that, beyond relieving pain, it allows patients to regain control of their lives. Studies have shown that, over time, patients who have undergone neuromodulation sessions can regain a level of physical and mental activity they had lost due to their chronic pain (MFAP, 2022).

3.3.5. Physical exercise and Transcranial Direct Current Stimulation (tDCS) in aging

In multicomponent physical exercise programs, stimulation techniques such as tDCS generate changes in cortical excitability and improve Executive Functions in the elderly population. Although tDCS can specifically target specific structures using high-definition tDCS stimulating systems, whose electrodes are smaller, such as the Dorsolateral Prefrontal Cortex Physical Exercise (DLPFC), it can target broader neural networks (Vaovelli *et al.,* 2017; Hanley and Tales, 2019; Steinberg *et al.,* 2019; Carrillo, 2024).

These effects of physical exercise produce a decrease in the activation of the prefrontal cortex, allocating resources to areas related to movement, such as the primary motor cortex or the striatum. This decrease in activity would result in a rebound effect, where the prefrontal region would experience an increase in oxygenated blood, improving prefrontal function. Thus, both techniques could present complementary effects at the functional level, with physical exercise interacting positively with the induction of plasticity (Figure 10) (Hanley and Tales, 2019; Steinberg *et al.,* 2019; Maudrich *et al.,* 2022; Carrillo, 2024).

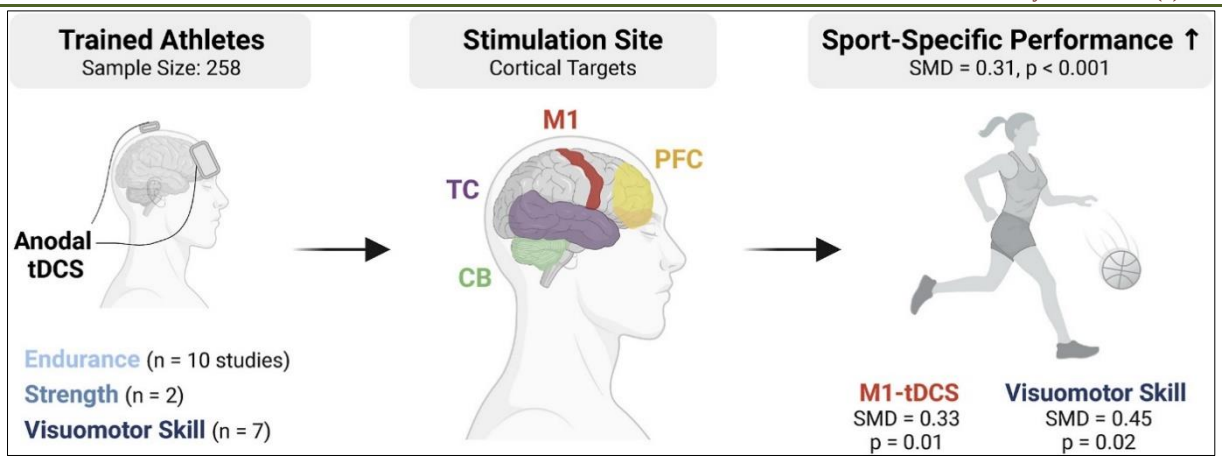

Figure 10: Single-session anodal transcranial direct current stimulation to enhance sport-specific performance in athletes: A systematic review and meta-analysis
Source: https://doi.org/10.1016/j.brs.2022.11.007

Synaptic stimulation is produced by cortical stimulation. For example, one of these techniques would improve the attentional control of executive functions by stimulating the DLPF, in their sample of women performing ultra-modal physical activity (Hanley and Tales, 2019; Steinberg *et al.*, 2019; Carrillo, 2024).

3.4. Neuromodulation to aid in the evaluation of athletes

3.4.1. Neuromodulation in elite sports

The greatness of football and its values are not only tests of physical skill and tactical strategy, but also celebrations of cultural diversity and unity. Over the years, these events have shown how sport can be a powerful vehicle for social inclusion and mutual understanding, forging a spirit of community and resilience between nations and cultures. For an elite athlete, simply staying at the top demands a dedication that few can sustain over time. Physical and mental recovery, stress management, and the constant pursuit of improvement at all levels define their daily lives. Well, it is precisely at this point where neuromodulation in elite sports comes into play (Figure 11) (Alexander *et al.*, 2022; Zikereya and Chen, 2023; NESA *Life*, 2025).

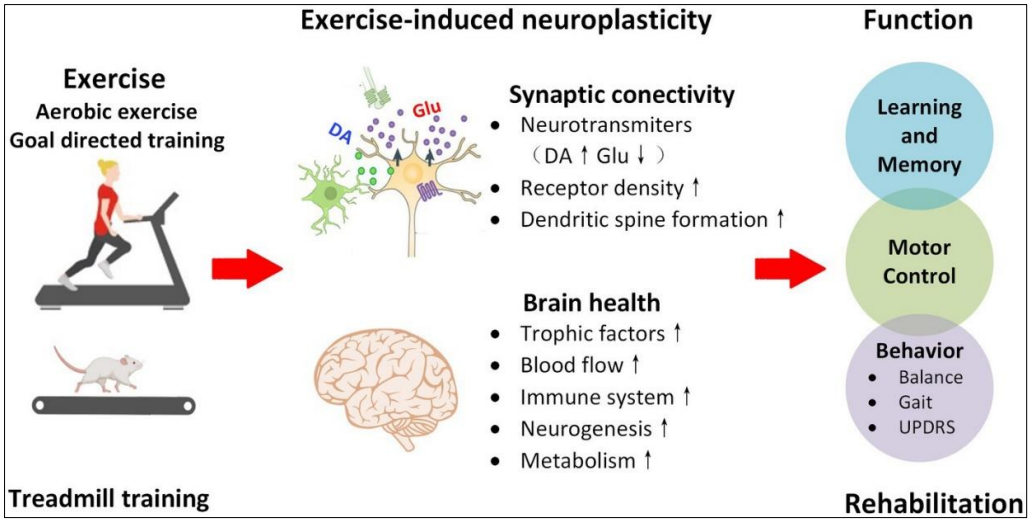

Figure 11: Goal-directed exercise can reduce the effects of oxidative stress, promote excitation-inhibition balance of DA-Glu neurotransmitters, and enhance synaptic structural and functional plasticity by regulating neurotransmitter conduction in DA and non-DA systems. In addition, exercise improves brain health by promoting the expression of neurotrophic and anti-inflammatory factors. Exercise-mediated neuroplasticity is the neural basis of PD motor control, learning, and memory, and improved behavioral performance
Source: 11: Doi: 10.3389/fneur.2023.1254447

3.4.2. Neuromodulation in elite sports: Juan Muro, physiotherapist for the 20-year national team

Introduces a concept that we find truly interesting: so-called invisible training. It's about having

all the technology, innovation, and training possible to ensure players perform at their best in every match, because being at 95% isn't enough here. You find that extra 5% to differentiate yourself from your competitors. Because that's what will make the difference [Real Madrid C.F. Physiotherapist Iván Ortega, speaking about the importance of taking care of the autonomic nervous system and doing so with NESA® Non-Invasive Neuromodulation] (Alexander *et al.,* 2022; NESA *Life,* 2025).

3.4.3. Neuromodulation: Five scientifically proven reasons:

1. **Concentration:** Increases the ability to concentrate and focus during critical moments, significantly improving the athlete's performance in this regard. Improved performance: Optimal physical performance and effective fatigue management are crucial for athletes who need to perform at their highest level. In this sense, neuromodulation in elite sports is positioned as an innovative solution for improving athletes' physiological recovery.
2. **Improved sleep quality:** This directly impacts the recovery process of elite athletes after a major match. As a key ingredient, they have been shown to regulate the ANS and also improve sleep quality by 60%.
3. **Post-match recovery:** Studies attest to the improvement in the speed with which players recover physically and mentally after a high-level match.
4. **Muscle fatigue:** Muscle fatigue caused by overexertion allows for more effective and frequent training. This has a direct impact on achieving set goals (NESA *Life,* 2025).

3.4.4. Recovery of the physiological status in professional basketball players using NESA neuromodulation

With the increase in specific competitive load during the regular basketball season, players have less time to train, and recovery between games is key to team performance in high-performance sports. Thus, "invisible training," understood as the set of habits, interventions, and strategies for optimal recovery, becomes a determining factor for optimal recovery (García *et al.,* 2022; NESA Words, 2025).

Instead of having electrodes attached to the chest to record breathing and heart rate during sleep (polysomnography), the Oura ring is a device that is almost imperceptible to players and offers very high validity and reliability. It is a seemingly ordinary ring capable of measuring countless sleep-related variables. The players quickly normalized it and were delighted to wear such a minimally invasive device (García *et al.,* 2022; NESA Words, 2025).

Noninvasive Neuromodulation (NESA®) is an advanced medical technique used to stimulate a person's nervous system without the need for surgery or invasive interventions. The goal of this stimulation is to regulate neuronal activity and improve the function of certain brain regions. In the recovery of elite players, this advanced medical technique can accelerate muscle recovery after intense exertion, allowing players to return to training more quickly [Franc García Garrido, lead author of the scientific study] (García *et al.,* 2022; NESA Words, 2025).

Three types of parameters were assessed over six weeks:

1. Common biomechanical markers: testosterone, cortisol, and their ratios.
2. Subjective well-being variables (sleep quality, stress, fatigue, and muscle soreness).
3. Heart rate-related variables measured using the Oura ring: heart rate variability, sleep duration, minimum and average heart rate, among others (Figure 12) (García *et al.,* 2022; Medina-Ramírez *et al.,* 2024; NESA Words, 2025).

Figure 12: A diagram representing the electrodes located on the wrist and ankles. The NESA device can be seen in the background

Source: Doi: https://doi.org/10.3390/stresses4020014

The essential pyramid of recovery is rest, nutrition and hydration, and quality personal relationships with family and friends. Having good habits in these areas seems to me to account for 95% of the success of recovery. In the remaining 5%, the NESA® strategy, along with other types of techniques, could have a place to obtain competitive advantages in high-performance sports [Franc García Garrido, lead author of the scientific study] (García *et al.*, 2022; NESA Words, 2025).

Neuromodulation reduces the pain signals that can persist after an injury, helping to prevent the development of chronic pain patterns. This allows the athletes to continue their rehabilitation without significant restrictions and with better control over their pain. Benefits:

1. Acceleration of the recovery process.
2. Reduction of chronic and acute pain.
3. Prevention of relapses and recurrent injuries.
4. Optimization of athletic performance.
5. Complete functional recovery (Abaïdia *et al.*, 2017; Arruda *et al.*, 2017; CAT, 2024).

3.4.5. Common sports injury cases treated with Neuromodulation:

1. **Knee injuries:** Knee injuries, such as ligament tears or patellar tendonitis, can be difficult to treat and carry a high risk of recurrence.
2. **Muscle tears:** In muscle tears, neuromodulation accelerates the healing process and helps restore the function of the injured muscle, reducing the risk of further tears.
3. **Tendinopathies:** Tendinopathies, such as Achilles tendonitis, respond favorably to neuromodulation, which reduces inflammation and improves tendon flexibility.
4. **Sprains and Strains:** Neuromodulation helps control inflammation and reduce pain in ankle sprains and other common sports injuries, facilitating faster rehabilitation (Abaïdia *et al.*, 2017; Arruda *et al.*, 2017; CAT, 2024).

3.4.6. Neuromodulation and injury recovery/benefits of in physical therapy

In the field of physical therapy, neuromodulation is like a master key that opens new doors to well-being and recovery. This innovative technique has multiple benefits that improve patients' quality of life:

1. Effective Pain Relief: One of the main benefits of neuromodulation in physical therapy is its ability to relieve chronic pain, where other traditional methods may not be sufficient.
2. Significantly reduce pain intensity, thus improving the patient's quality of life.
3. Recovery of Motor Function: Improves mobility and motor function, especially in patients who have suffered injuries or suffer from neurological diseases.
4. Helps restore normal movement patterns, facilitating recovery and return to daily activities.
5. Reduction of medication dependence (Figure 13) (Greenham *et al.*, 2018; Gómez *et al.*, 2019; Evancho *et al.*, 2023; Efisio.es, 2025).

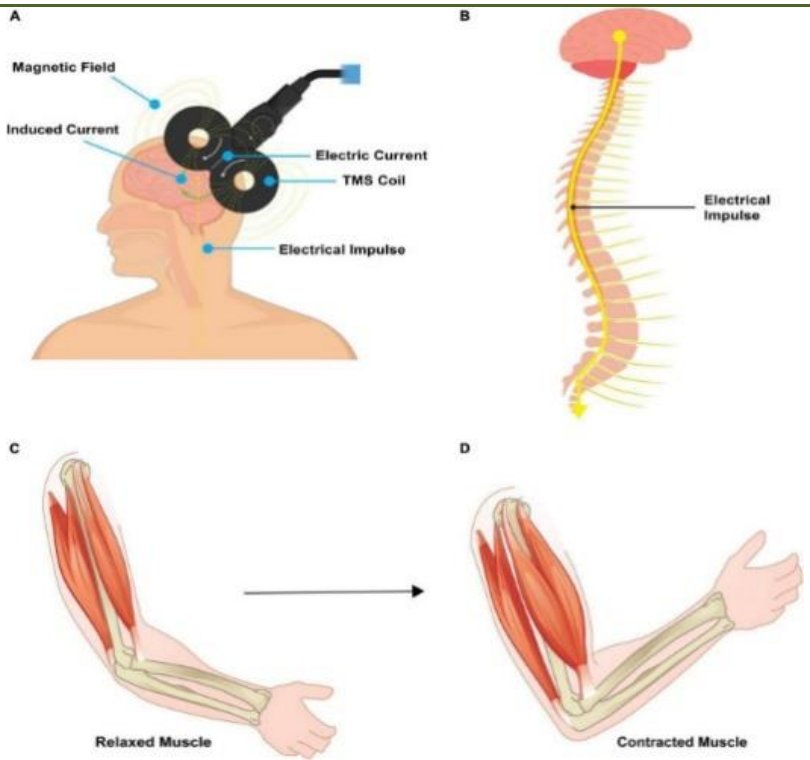

Figure 13: (A) Transcranial magnetic stimulation involves placement of a magnet coil over the scalp to induce an electric field. This electric field passes through the scalp and skull to act directly on the targeted brain area. (B) When applied to the primary motor cortex, an electrical impulse travels down the corticospinal tract in a targeted muscle contraction. (C, D) A relaxed muscle will contract with targeted TMS

Sources: Biorender.com and Doi: 10.3389/fnhum.2023.1151218

Neuromodulation offers an alternative for those who rely heavily on medications for pain management. By effectively providing relief, it reduces the need for medication, thereby decreasing the risks and side effects associated with prolonged use. The application of neuromodulation in physical therapy opens up a world of possibilities for the treatment of various conditions, offering patients a path to a more active and pain-free life (Greenham *et al.*, 2018; Gómez *et al.*, 2019; Efisio.es., 2025).

3.5. Neuroplasticity: Benefits of jiu jitsu for the autistic brain

3.5.1. Autism Spectrum Disorder (ASD)

ASD is a complex neurodevelopmental disorder described by a variety of symptoms and signs, including the presence of repetitive and stereotyped behaviors, difficulties in social interaction, language, and communication skills. Children with ASD have low physical activity levels, a sedentary lifestyle, and low exercise tolerance (Figure 14) (Van *et al.*, 2010; Rosa and Rodrigues, 2014).

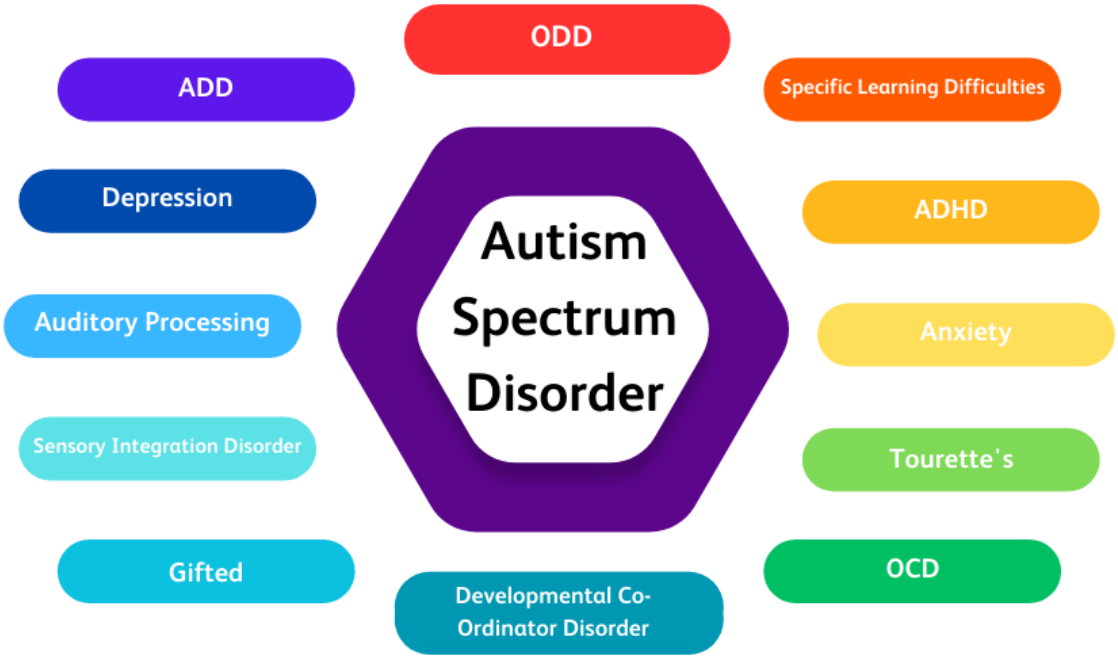

Figure 14: Exploring the Different Forms of Autism: You can see the different behaviours that are registered on the autism spectrum

Sources: www.nurseplusuk.com, Asperger's Syndrome, © Copyright 2025 Nurseplus and https://www.nurseplusuk.com/blog/2023/04/signs-and-symptoms-of-autism?source=goldenstepsaba.com

Motor skills are also typically poor or delayed due to motor deficits, and it is known that atypical motor planning impairments may reveal dysfunctions in brain regions such as the basal ganglia or the cerebellum (American Psychiatric Association - DSM-5 Task Force, 2013; Rosa and Rodrigues, 2014).

3.5.2. Jiu-Jitsu can provide multiple benefits

For children with autism, developing social skills, improving motor coordination, and increasing confidence. Practicing Jiu-Jitsu promotes neuroplasticity, the brain's ability to adapt and form new neural connections. This can be especially beneficial for children with autism, as Jiu-Jitsu helps strengthen areas of the brain that may be less developed. Physical and emotional benefits: The practice improves strength, motor coordination, and reflexes, in addition to helping regulate metabolism and strengthen the cardiovascular system (Van *et al.*, 2010; American Psychiatric Association - DSM-5 Task Force, 2013; Rosa and Rodrigues, 2014).

Jiu-Jitsu is an excellent tool for children with autism, providing physical and emotional benefits. The practice improves strength, motor coordination, and reflexes, in addition to helping regulate metabolism and strengthen the cardiovascular system. On the mental side, Jiu-Jitsu helps control anxiety, improves sleep quality, and develops self-confidence. In addition, it encourages socialization, focus, and cooperation (Figure 15) (Van *et al.*, 2010; American Psychiatric Association, DSM-5 Task Force, 2013; Rosa and Rodrigues, 2014).

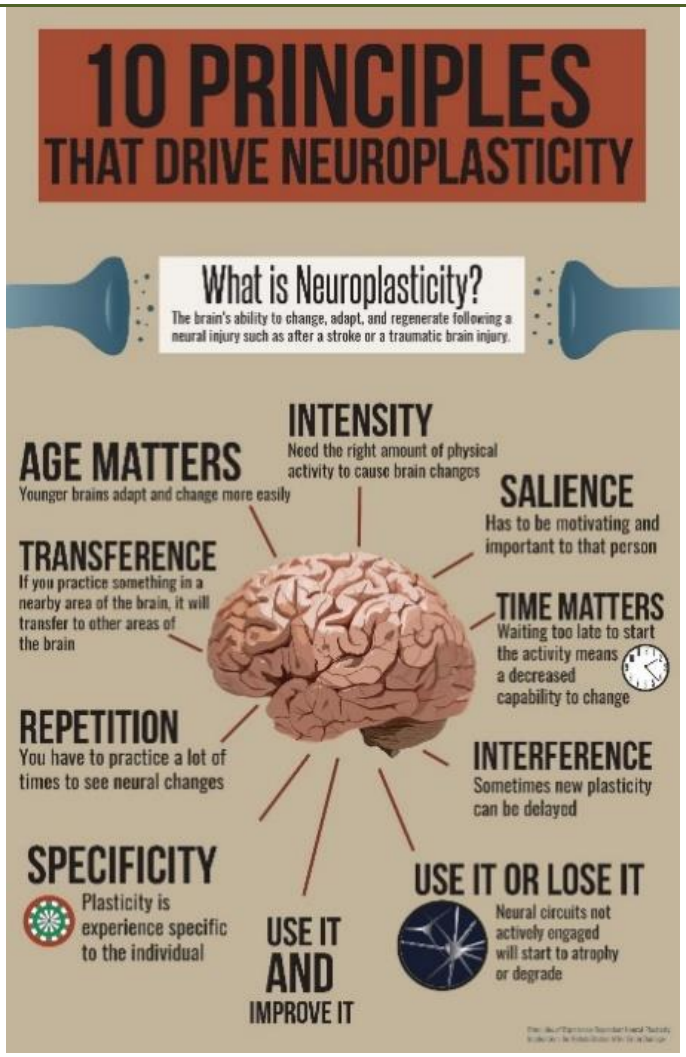

Figure 15: Graphic Design, Caroline Walker

Sources: Caroline Walker Medical Animations, Applications, & Design and https://www.carolinemwalker.com/graphic-design

According to Lima *et al.* (2021), the results indicate a significant improvement in the experimental group, after the Jiu-Jitsu intervention, in manipulative performance, self-care, social function, and less help from parents to carry out tasks. It is possible to conclude that this modality can be an instrument for ASD and contribute to the planning of interventions and assistance to coaches and health professionals (CDCP, 2019).

3.5.3. Publication by the Municipal Government of Gália (Spain): The social project: Transforming lives in Gália, José Guilherme's journey in Jiu-Jitsu: Case Report

José Guilherme trains in the project with his sister, Isabela, and his father, Thiago Cazane, forming a true family team within the dojo. From the first day, the boy showed determination and a desire to learn, proving that jiu-jitsu can be a great ally for children within the autistic spectrum. Recently, José Guilherme had the opportunity to test his skills in an official competition (Facebook, 2025).

With determination and technique, he competed in three fights, winning two and losing one. More than the results, the experience brought valuable lessons about resilience, emotional control, and self-confidence. "It was incredible to see José Guilherme competing. He showed enormous progress and impressive discipline," he said. "Jiu-jitsu has a very positive impact on the development of children with autism, helping with concentration, social interaction, and anxiety control" [Ricardo Wester] (Facebook, 2025).

3.5.3.1. The benefits of jiu-jitsu for children with autism

Jiu-jitsu has proven to be a powerful tool in the inclusion of autistic children. Among the main benefits of the practice are: Improved motor coordination. The

movements require balance, control, and precision, helping with physical development:

1. Increased concentration.
2. Reduced anxiety.
3. Strengthened social bonds (Figure 16).

Figure 16: Jiu-jitsu instruction manual

Source: Lisa – pim.cpcompany.com, and https://pim.cpcompany.com/dedu/historia-do-jiu-jitsu.html

Inclusion begins with an opportunity, and often this opportunity is on the mat (Facebook, 2025).

3.5.3.2. Felipe Nilo and the 5 benefits of Jiu-Jitsu for autistic children

In autistic children or young people, aggression can occur due to frustration or an inability to express a feeling in the desired way. With this in mind, he indicates that martial arts can help reduce these impulses but emphasizes that special care must be taken when choosing the training location [GMI Teacher Felipe Nilo] (Graciemag Newsroom, 2021).

A graduate in Jiu-Jitsu and judo, Felipe currently leads a sports clinic on teaching children and young people with autism. The initiative was a pioneer in Brazil and is recognized worldwide as a step forward for inclusion in sports. "It is necessary to seek appropriate support and learn some methodologies. A black belt does not mean the teacher knows what he is doing," explains [GMI Teacher Felipe Nilo] (Graciemag Newsroom, 2021).

To reinforce the positive impact of fighting, Felipe separated five aspects on the mats that can improve the lives of autistic people:

1. Self-control.
2. Dealing with frustrations.
3. Self-control.
4. Discipline and respect.
5. Hierarchy.

3.6. Muscle memory

Like the idea of the muscle that reminds you how to, she adds that it is much more than that: "For a movement to become automatic, it must be performed repeatedly in various contexts. The individual has to record the errors that occurred so that the nervous system records the sequences of neurons that are most successful in making that movement happen. So, when I perform a movement for the first time or the first few times, I have a high demand on several areas of my nervous system. From this, areas of my brain, of my cerebral cortex, related to this intention are activated talk to other areas requesting some help so that this movement can be planned" [Physiotherapist Andrea Peterson Zomignani, PhD in Neuroscience and Behavior from the Institute of Psychology at USP] (Ueno, A - USP Journal, 2023).

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requesting some help so that this movement can be planned" [Physiotherapist Andrea Peterson Zomignani, PhD in Neuroscience and Behavior from the Institute of Psychology at USP] (Figure 17) (Ueno, A - USP Journal, 2023).

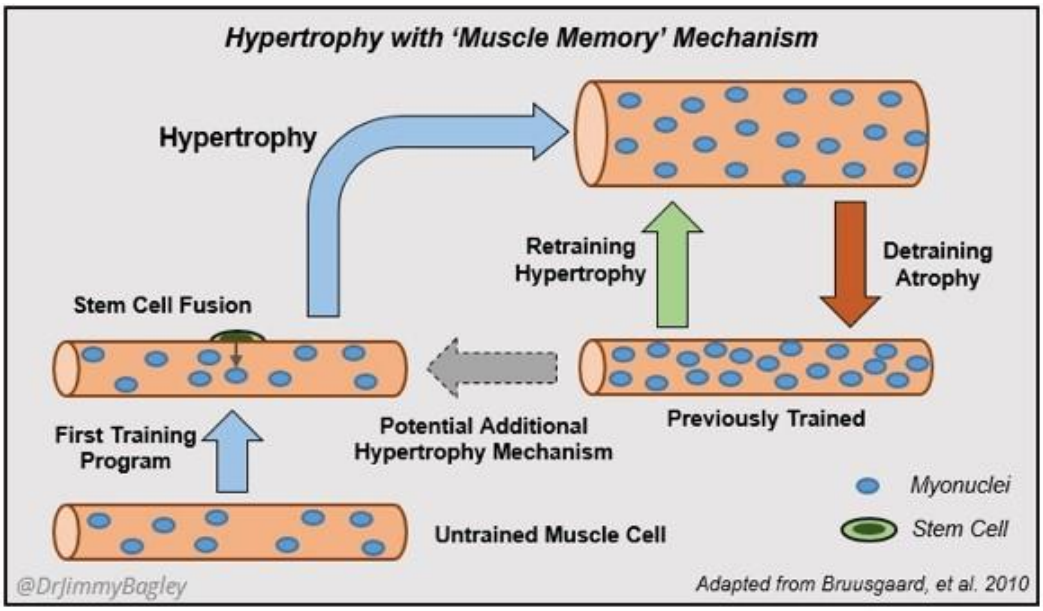

Figure 17: Stopping training and "muscle memory."
Source: Ojeda, J. (2016). Stopping training and "muscle memory." Retrieved May, 10, 2025, from https://juanjeojeda.com/dejar-entrenar-memoria-muscular/

As important as muscle fibers are for automated movement, the nervous system and its components are behind the scenes. "It is a memory that, although it acts to cause muscle contractions, is stored within the nervous system, and these muscles are only activated because the nervous system is capable of managing this muscle activation in a certain order. We are talking about the automation of movements," says the physiotherapist [Physiotherapist Andrea Peterson Zomignani, PhD in Neuroscience and Behavior from the Institute of Psychology at USP] (Ueno, A - USP Journal, 2023).

"For automatic movement to occur, the nervous system, especially the basal ganglia region, is heavily involved in constructing engrams. These sequences of neural network activation will consequently activate certain muscles so that a motor action can occur. Therefore, these engrams are essential," explains Andrea [Physiotherapist Andrea Peterson Zomignani, PhD in Neuroscience and Behavior from the Institute of Psychology at USP] (Ueno, A - USP Journal, 2023).

muscle mass, known as sarcopenia, is a common problem that impacts functionality and quality of life. Muscle memory, however, can be a powerful ally in reversing this condition. Studies show that individuals who performed strength exercises earlier in life can recover muscle mass more efficiently in old age. Research indicates that these structures can remain stable for up to 15 years, or even permanently, in humans. This highlights the importance of starting strength training as soon as possible to ensure a functional reserve that can be used later (Pessoa and Gonçalves, 2024).

Studies have suggested that this effect can be explained by neural adaptations, both in the brain and in peripheral nerves, but mainly by "exclusively" muscular adaptations related to two theories: (i) Cellular muscle "memory", (ii) Molecular or epigenetic muscle "memory". But what is cellular "memory"? This memory refers to adaptations that occur in the structure and organization of muscle cell compartments, including an increase in the number of new nuclei. This type of adaptation is important for increasing DNA, a molecule that contains all of the organism's genetic information. And what about molecular "memory"? It refers to modifications in muscle DNA, such as methylation, but without changes in the sequence or quantity of DNA (Figures 18-19) (Pessoa and Gonçalves, 2024).

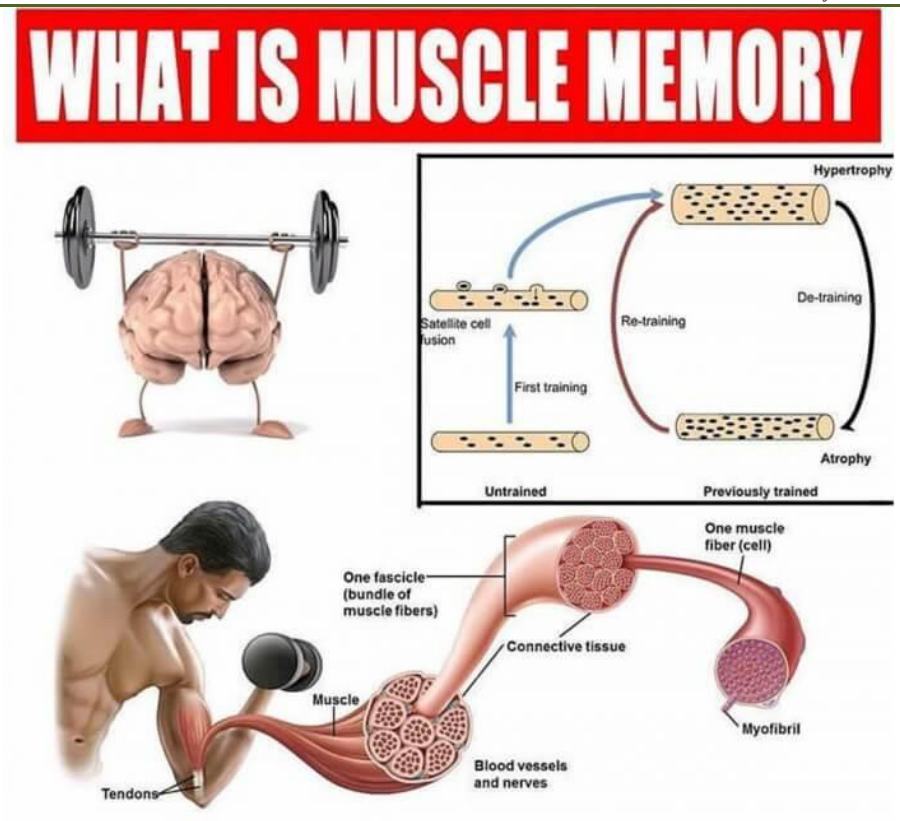

Figure 18: Cellular muscle "memory" theory

Source: https://santabarbaradeeptissue.com/index.php/2019/02/28/holistic-muscle-pain-massage-therapy-solutions-2/

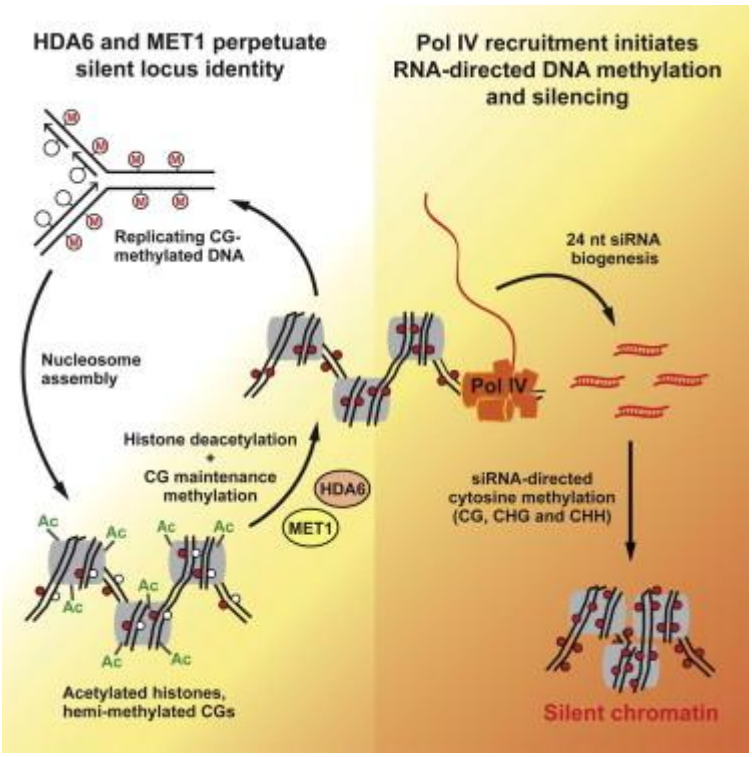

Figure 19: Epigenetic inheritance is a two-step process, with a heritable molecular memory first forming to maintain a chromatin state required later for actual silencing of a genetic locus

Sources: Author: About Bailey Kirkpatrick, Photo by Craig Pikaard and Todd Blevins, and https://www.whatisepigenetics.com/molecular-memory-and-a-two-step-process-of-epigenetic-inheritance/

Both types of memory could lead to changes in the expression of genes related to muscle growth hypertrophy, strength, or fatigue resistance, and these changes would be retained during detraining, accelerating muscle adaptation during retraining. Understanding "muscle memory" may help more effective interventions for physical conditioning after a period of physical inactivity, but also in understanding the mechanisms of "molecular reconfiguration" stimulated by physical exercise in muscles of elderly or sick individuals (Pessoa and Gonçalves, 2024).

4.0. CONCLUSION

Neuromodulation can enhance neuroplasticity, which improves. For example, it can be used to treat disorders such as depression, schizophrenia, and Parkinson's disease, or to restore motor, cognitive, or speech functions. Physical activity offers multiple health benefits for everyone, at any age, and for both women and men. Neuromodulation for those suffering from muscle overload, including: Pain reduction, improved neuromotor control, increased muscle performance, and accelerated rehabilitation, children with autism, developing social skills, improving motor coordination, and increasing confidence. Practicing Jiu-Jitsu promotes neuroplasticity, the brain's ability to adapt and form new neural connections. This can be especially beneficial for children with autism, as Jiu-Jitsu helps strengthen areas of the brain that may be less developed. Muscle memory involves repetition and has the nervous system as its main tool.

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