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REVIEW ARTICLE

Influence of extrinsic feedback and physical therapy care on the recovery of patients following a stroke

Influencia de la retroalimentación extrínseca y la atención fisioterapéutica en la recuperación del paciente tras un accidente cerebrovascular

Influência do feedback extrínseco e atenção fisioterapêutica na recuperação do paciente pós acidente vascular encefálico

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Abstract

This study aimed to investigate the influence of extrinsic feedback and physiotherapeutic care on the recovery of patients following a stroke. It is an integrative review with a qualitative and descriptive approach, based on articles from the SciELO and PubMed databases, as well as a repository of theses and dissertations, covering publications from 2010 to 2023. The results indicate that extrinsic feedback, particularly visual and auditory, is effective for postural correction and the enhancement of motor control. Technologies such as biofeedback and virtual reality have been shown to increase patient motivation, making sessions more interactive. Tactile feedback, provided through the physical touch of the physiotherapist, also aids in the patients' body perception and motor awareness. The combination of sensory feedback and humanized care strengthens the bond between the physiotherapist and the patient, fostering greater engagement and trust. It is concluded that extrinsic feedback and humanized physiotherapeutic care are valuable tools in post-stroke rehabilitation, as they support motor recovery, increase treatment adherence, and contribute to an improved quality of life.

Descriptors: Extrinsic Feedback; Stroke; Sensory Feedback; Rehabilitation; Neuroplasticity.

Resumén

El objetivo fue investigar la influencia de la retroalimentación extrínseca y la atención fisioterapéutica en la recuperación de pacientes tras un accidente cerebrovascular (ACV). Se trata de una revisión integrativa de enfoque cualitativo y descriptivo, basada en artículos de las bases de datos SciELO y PubMed, así como en repositorios de tesis y disertaciones, con publicaciones comprendidas entre 2010 y 2023. Los resultados indican que la retroalimentación extrínseca, especialmente la visual y la auditiva, es eficaz para la corrección postural y la mejora del control motor. Tecnologías como el biofeedback y la realidad virtual han demostrado aumentar la motivación de los pacientes, haciendo que las sesiones sean más interactivas. La retroalimentación táctil, proporcionada mediante el contacto físico del fisioterapeuta, también contribuyó a la percepción corporal y a la conciencia motora de los pacientes. La combinación de retroalimentación sensorial y prácticas humanizadas fortalece el vínculo entre el fisioterapeuta y el paciente, promoviendo una mayor implicación y confianza. Se concluye que la retroalimentación extrínseca y la atención fisioterapéutica humanizada constituyen herramientas valiosas en la rehabilitación tras un ACV, ya que favorecen la recuperación motora, aumentan la adherencia al tratamiento y contribuyen a mejorar la calidad de vida.

Descriptores: Retroalimentación extrínseca; Accidente cerebrovascular; Retroalimentación sensorial; Rehabilitación; Neuroplasticidad.

Resumo

Objetivou-se investigar a influência do feedback extrínseco e a atenção fisioterapêutica na recuperação de pacientes pós acidente vascular encefálico. Trata-se de uma revisão integrativa de abordagem qualitativa e descritiva, baseada em artigos das bases de dados SciELO, PubMed e banco de teses e dissertações, com publicações entre 2010 e 2023. Os resultados indicam que o feedback extrínseco, especialmente o visual e o auditivo, é eficaz na correção postural e no aprimoramento do controle motor. Tecnologias como biofeedback e realidade virtual demonstraram elevar a motivação dos pacientes, tornando as sessões mais interativas. O feedback tátil, dado pelo toque do fisioterapeuta, também ajudou na percepção corporal e na conscientização motora dos pacientes. A combinação de feedback sensorial e práticas humanizadas fortalece o vínculo entre fisioterapeuta e paciente, promovendo maior engajamento e confiança. Conclui-se que o feedback extrínseco e a atenção fisioterapêutica humanizada são ferramentas valiosas na reabilitação pós-AVE, pois favorecem a recuperação motora, aumentam a adesão ao tratamento e contribuem para a melhoria da qualidade de vida.

Descritores: Feedback Extrínseco; Acidente Vascular Cerebral; Feedback Sensorial; Reabilitação; Neuroplasticidade.

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Introduction

Stroke is a neurological impairment resulting from the blockage or rupture of blood vessels, causing brain damage. It is among the leading causes of death and hospitalization worldwide, affecting adults and older adults of both sexes, with a higher incidence among individuals over 65 years of ages[1].

There are two types of stroke: ischemic stroke, characterized by the obstruction of one or more arteries due to thrombosis, embolism, or atherosclerosis, resulting in interrupted blood flow (85% of cases); and hemorrhagic stroke, characterized by bleeding into the cranial cavity due to the rupture of an artery or blood vessel (15% of cases)[2].

Cerebral vascularization is divided into the carotid territory, which includes the ophthalmic, middle cerebral, and anterior cerebral arteries. Lesions in this territory may result in visual disturbances, motor and sensory deficits, aphasia, neglect, disinhibition, and impulsivity. The other territory comprises the vertebrobasilar and cerebellar circulation, and lesions affecting these regions may cause decreased consciousness, nausea, vomiting, dizziness, dysarthria, dysphagia, difficulty forming words, motor and sensory deficits, diplopia, vertigo, impaired coordination, among other manifestations[3].

Several factors contribute to stroke and are classified as modifiable or non-modifiable. The most common modifiable risk factor is systemic arterial hypertension (SAH); other factors include obesity, alcoholism, physical inactivity, and diabetes mellitus (DM), among others. Non-modifiable risk factors include age, sex, race, and heredity[1].

The risk of stroke is twice as high in individuals over 55 years of age. It affects men more frequently up to the age of 85, after which this pattern reverses in favor of women, due to their longer life expectancy. Stroke is also twice as common among Black individuals. The main symptoms are of vascular origin and include localized headache, dysarthria, blurred vision, dysphasia, and motor and sensory deficits[4].

Patients who experience a stroke may develop severe sequelae, depending on the arterial territory involved and the size of the ischemic area. In addition to neurological deficits, patients may also present motor impairments, such as hemiparesis or hemiplegia, consequently resulting in gait and balance disturbances and functional limitations[5].

Hemiparesis is a motor impairment that may manifest through various neurological signs affecting the side of the body corresponding to the damaged brain area. Patients with hemiparesis experience postural instability, shifting their center of gravity toward the unaffected side and consequently adopting an asymmetric posture. This occurs due to reduced muscle strength and impaired sensory input, combined with compensatory movements, resulting in deficient functional balance[6].

The affected muscles are antigravity muscles, resulting in an extensor pattern in the lower limb, in which the individual presents hip internal rotation and adduction, partial knee flexion, ankle plantar flexion, and foot inversion. In the upper limb, the flexor pattern is characterized by shoulder protraction and adduction, elbow flexion, forearm pronation, wrist flexion, finger flexion, and thumb adduction[7].

Patients who have experienced a stroke may exhibit abduction of the affected lower limb during the swing phase of gait, in addition to difficulty with knee and hip flexion and foot dorsiflexion, resulting in muscle fatigue. This limitation in dorsiflexion may be associated with muscle spasticity of the ankle plantar flexors and invertors, leading to an equinovarus foot[8].

Another possible sequela of stroke is urinary incontinence, defined as the involuntary loss of urine. It may be classified as urge urinary incontinence (the sensation of urgency), stress urinary incontinence (urine loss during physical exertion, such as coughing), or mixed urinary incontinence (a combination of the two aforementioned types). Damage to the neural pathways involved in micturition caused by stroke is the most common cause of urinary incontinence. This condition may affect patients' physical and psychological well-being, compromising their integrity and causing dermatitis and urinary tract infections, in addition to embarrassment[9].

These consequences compromise quality of life and independence in activities of daily living. Clinical interventions adopted for balance and gait rehabilitation are based on the principles of neuroplasticity, which refers to the brain's ability to recover a function through synaptic interactions, neural migration and proliferation, and motor learning[10].

Neuroplasticity and motor learning are interconnected. When new learning occurs, the brain is responsible for storing it. This process generates plasticity, meaning that new neural connections are formed (or eliminated) to store what has been learned, enabling the retrieval of new information or skills[11].

According to Bastos et al.[12], neuroplasticity involves the process by which, following an injury to the Central Nervous System (CNS), intact neurons seek alternative pathways to produce the motor response that has been impaired, forming synapses with modified neurons, after which different neural pathways and circuits are sought.

According to Germoglio et al.[3], when an injury occurs in the central nervous system, the neuronal chain is disrupted, resulting in altered neural signal transmission. Thus, when the Babinski sign is present, it indicates an injury affecting upper motor neuron function, characterized by weakness and signs of pyramidal tract dysfunction, such as increased tendon reflexes, spasticity, and a positive Babinski sign.

Upper motor neuron injury causes spasticity, which may lead to pain, contractions, and deformities. This neurological alteration causes agonist muscles to act simultaneously and with the same intensity as antagonist muscles, resulting in movement restriction and hindering patient recovery. Coordinated muscle contraction occurs through reciprocal inhibition, which is impaired in this type of injury[13].

According to Dias et al.[14], there are two important types of receptors in the muscle spindle: one is referred to as muscarinic and is responsible for maintaining normal

muscle tone, while the second regulates increased muscle tone and is referred to as nicotinic. Both are stimulated by a neurotransmitter called acetylcholine (ACh), which is in the autonomic nervous system. Therefore, following a stroke, muscarinic receptors are blocked, causing a loss of muscle tone regulation, while nicotinic receptors are stimulated, resulting in increased muscle tone and spasticity.

When early stimulation is provided, neuroplasticity can be induced, supporting changes in neurological circuits within the gray matter of the brain's motor and sensory areas. These stimuli may alter neuronal function, chemical profile, and structure, facilitating recovery from CNS injury[15].

According to Fernandes[16], in the 1950s, Paul Fitts proposed the theory that motor learning involved progression through several stages with distinct characteristics, related to an individual's information-processing capacity. Three stages of motor learning were described: the cognitive stage, which corresponds to what the individual needs to know and which strategy to use to perform a task; the associative stage, involving the refinement of skills; and the autonomous stage, corresponding to the automation of movement.

There are three phases following a stroke. The flaccid phase is characterized by hypotonia and severe motor and sensory loss. During this phase, the affected side of the body is impaired, preventing the patient from maintaining a standing position due to hypotonia and muscle weakness. The recovery phase is characterized by the progression from hypotonia toward normal muscle tone. Finally, the spastic phase involves the development of hypertonia and spasticity, with initial recovery of proximal movements. The degree of spasticity varies according to the extent and severity of the central nervous system injury[17].

Spasticity is a motor disorder resulting from upper motor neuron injury, characterized by increased muscle tone, exaggerated reflexes, and velocity dependence. It may lead to muscle shortening, pain, postural changes, and difficulties performing activities of daily living[18]. It is associated with elastic hypertonia, tendon hyperreflexia, and a positive Babinski sign, which interfere with general mobility and walking ability, resulting in reduced gait speed and increased energy expenditure, ultimately leading to less functional gait[19].

In the rehabilitation process, motor learning is essential, and one of the most important ways in which it occurs is through practice. Furthermore, feedback provided by the physical therapist is an essential variable in motor skill acquisition[20].

Feedback is defined as all types of sensory information received during and after the execution of a movement and is referred to as response-produced or movement-produced feedback. There are two types of feedback: intrinsic and extrinsic. Intrinsic feedback consists of sensory information naturally generated by movement, that is, information received by individuals through their own sensory systems during or after movement. It is also referred to as inherent feedback and may originate from internal sources within the body (exteroceptive, proprioceptive, visual, or other information) or from external sources[21].

According to Soares[22], when the sensory system is impaired, patients may be unable to detect their errors accurately, making it necessary to provide information through extrinsic feedback.

Extrinsic feedback involves information provided by an external source, that is, information originating outside the individual's physiological system. Both types of feedback are important for acquiring new skills[23]. Extrinsic feedback can be used in several ways, including visual feedback through mirrors, visual cues, videos, or real-time feedback, helping patients observe their movements and correct their posture during rehabilitation. Tactile feedback involves the physical therapist using touch and pressure to help improve sensory perception, proprioception, and motor control. Auditory feedback, such as verbal instructions or specific sounds, may be used to guide patients, assisting with rhythm, cadence, and movement coordination. Finally, external feedback provided by technological devices, such as biofeedback systems, virtual reality, and sensors, may be used to monitor muscle activity, balance, posture, and motor performance, supporting the assessment and monitoring of rehabilitatio[24].

This type of feedback plays a significant role in the treatment of post-stroke patients by providing sensory information that supports rehabilitation and improves neuromuscular function. It enhances the perception and execution of movements through touch, vision, and hearing, helping correct motor patterns and increasing body awareness by enabling patients to better understand their body position and movements during rehabilitation. Feedback also stimulates motor learning by providing clear and immediate information about movement execution. Furthermore, it motivates patients to make greater efforts during treatment by providing visual, auditory, or tactile reinforcement that supports performance and improvement[23].

Based on the feedback received during physical therapy sessions, the professional can adjust treatment intensity and progression according to the patient's needs and abilities, enabling the achievement of therapeutic goals[25].

Physical therapy directly addresses pain and patient recovery, whether involving motor, neurological, or respiratory conditions, using manual treatment techniques. Providing humane care is extremely important for establishing patients' trust in their therapists, thereby positively influencing treatment outcomes[26]. Humanizing care means providing patients with high-quality treatment, valuing the individual, and ensuring respect, dignity, and autonomy, based on the ability to speak and listen and on the appreciation of dialogue between the therapist and the patient[27].

Physical therapists must establish a meaningful connection with individuals, integrating ethics and science rather than relying solely on technical and scientific knowledge. In other words, physical therapy is not limited to prevention, treatment, and rehabilitation; it also aims to

promote individual and collective well-being, rehabilitating patients and reintegrating them into social life[28].

Physical therapy is extremely important in the rehabilitation of patients after stroke, considering that these individuals may experience several sequelae, including physical and psychological changes ranging from sadness to depression. In this context, physical therapists must identify impaired functions and stimulate them with the aim of improving functionality, facilitating patients' readaptation to their social environment, and consequently enhancing their quality of life[29].

During rehabilitation, physical therapy plays an important role in reducing the negative impacts of complications resulting from these sequelae, contributing to recovery and minimizing functional limitations[30]. Following a stroke, several factors influence patients' health and rehabilitation process. Conditioning factors must be considered, as they may affect recovery and treatment adherence. Patients' housing conditions may influence recovery, since accessibility, safety, and comfort in the home environment are essential factors in facilitating mobility and independence. Regarding nutrition, a balanced diet may contribute to cardiovascular health, weight control, and the prevention of disease-related complications[31].

Another factor influencing this process is daily lifestyle, including physical activity, adequate sleep, stress management, and the abandonment of harmful habits, such as smoking and excessive alcohol consumption. Finally, family support is essential for patients' emotional well-being and motivation, directly influencing treatment adherence and rehabilitation outcomes[32].

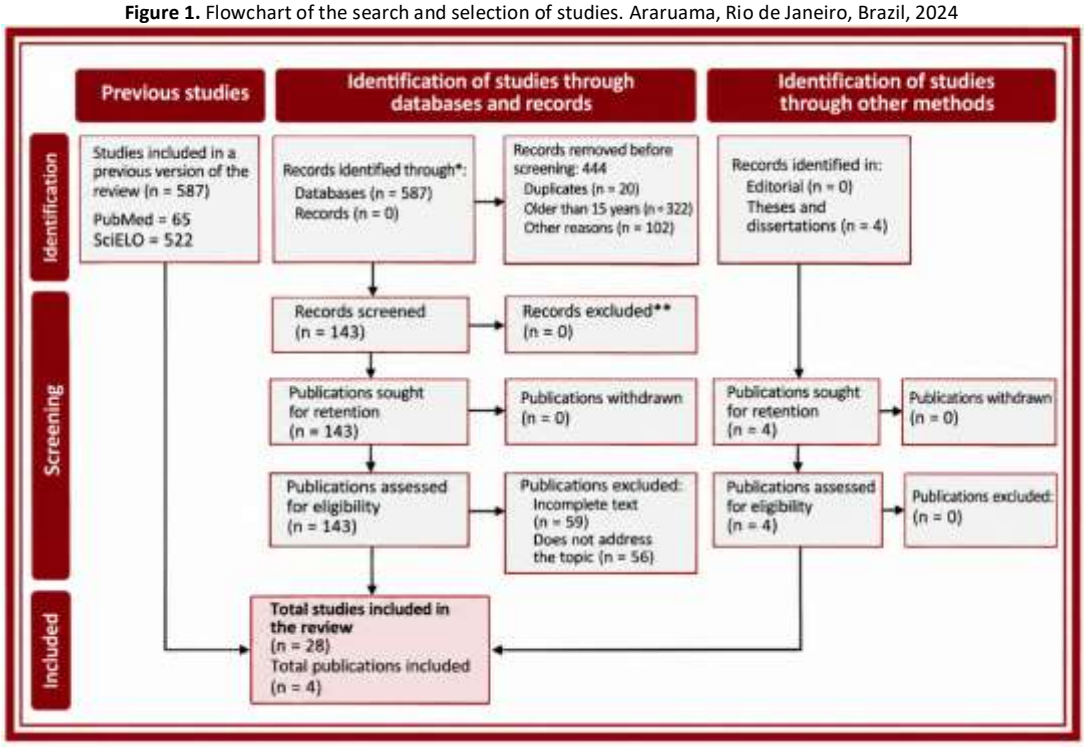
In view of this, physical therapists must adopt a sensitive approach to these health-related conditioning factors, understanding patients' social, emotional, and environmental contexts to develop effective treatment strategies that promote treatment adherence and encourage active participation and engagement in rehabilitation[29].

Based on these considerations, the objective of this study is to investigate the influence of extrinsic feedback and physical therapy care on the treatment of a patient who has experienced a stroke.

Methodology

The study consisted of an integrative literature review with a qualitative and descriptive approach. The search strategy included references retrieved from the Scientific Electronic Library Online (SciELO), PubMed, and the Brazilian Digital Library of Theses and Dissertations. The following descriptors were used to screen the studies: stroke; extrinsic feedback; neuroplasticity; rehabilitation; and stroke.

Figure 1. Flowchart of the search and selection of studies. Araruama, Rio de Janeiro, Brazil, 2024



The searches were based on the following research question: "How can extrinsic feedback and the physical therapist's attention influence the treatment of a patient who has experienced a stroke?". Studies published between 2010 and 2023, in Portuguese and English, were included if they addressed stroke, post-stroke rehabilitation, the definition and use of extrinsic feedback, physical therapy involving these resources, and patient rehabilitation using extrinsic stimuli. The exclusion criteria were studies published before 2010, duplicate studies, studies for which the full text was unavailable, studies published in other languages, and studies unrelated to the topic.

The material selection process was conducted between January and August 2024. A total of 587 publications were identified in the aforementioned databases using the descriptors listed above. The process

was carried out as follows: the initial search in the SciELO database identified 522 publications. Articles published before 2010 were excluded, totaling 300 studies, leaving 222 articles. Subsequently, 70 articles with restricted access, 52 with incomplete full texts, 30 published in other languages, and 20 duplicates were excluded, leaving 50 articles. The remaining articles were analyzed, and 40 were found to focus on topics unrelated to the subject of this study. Therefore, only 10 publications were considered relevant to the research and included in the proposed study. In PubMed, 65 publications were initially identified. Subsequently, 22 articles published before 2010 were excluded, leaving 43. Next, 7 articles with incomplete full texts and 2 published in other languages were excluded, leaving 34 articles. The remaining articles were analyzed, and 16 were found to focus on topics unrelated to the subject of this study. Thus, only 18 publications were considered relevant to the research and included in the proposed study. Additionally, 4 studies retrieved from the database of theses and dissertations were used. Therefore, a total of 32 articles were included in the development of this study.

Results

The chart below summarizes five references related to the main themes addressed in the results. Therefore, it represents a selection of the references rather than a complete characterization of all 32 documents.

Chart 1. Characterization and synthesis of references on extrinsic feedback and physical therapy care in post-stroke rehabilitation. Araruama, Rio de Janeiro, Brazil, 2024

Author and year	Study design and sample	Objective	Main findings	Limitations and relevance to the topic
Soares (2017)	Experimental study; 20 post-stroke individuals and 20 healthy individuals.	To compare knowledge of performance and knowledge of results in learning a pointing task.	The post-stroke group that received knowledge of performance demonstrated task learning; the group that received knowledge of results did not demonstrate learning based on the scores.	Provides direct evidence on post-stroke feedback, limited to the upper-limb task investigated.
Cano Porras et al. (2019)	Retrospective study; medical records of 167 patients with different clinical conditions, including stroke.	To analyze the clinical use of virtual reality in balance and gait rehabilitation.	Improvements in balance, gait, and balance confidence were observed. The post-stroke group showed a reduction in dual-task cost during walking.	The diversity of diagnoses and retrospective design limit the attribution of improvements exclusively to virtual reality.
Jiménez-Díaz, Chaves-Castro e Morera-Castro (2021)	Meta-analysis; 20 studies representing 949 participants.	To examine the effects of augmented feedback on motor skill performance and learning.	Performance improved during acquisition and declined after feedback withdrawal during retention. Knowledge of performance showed more favorable results for maintaining performance.	The population was not exclusively composed of individuals with stroke; application to neurological rehabilitation requires caution.
Zilli, Lima e Kohler (2014)	Literature review; four selected articles.	To analyze neuroplasticity in the rehabilitation of patients with spastic stroke.	The studies reported favorable results for constraint-induced movement therapy, associated with motor performance and cortical reorganization.	Provides a basis for discussing neuroplasticity but does not independently assess the effects of extrinsic feedback.
Tocci e Costa (2014)	Literature review on humanization and management within the Brazilian Unified Health System (SUS); sample not specified in the abstract consulted.	To discuss changes in healthcare delivery and management following the National Humanization Policy.	Highlights welcoming care, qualified listening, comprehensive care, and appreciation of the individual.	Provides a foundation for discussing humanized care but does not directly assess motor recovery or adherence to post-stroke physical therapy.

Based on the literature review, the findings indicate that extrinsic feedback plays a fundamental role in the rehabilitation of patients who have experienced a stroke. According to Chiviacowsky et al.[21], the use of visual feedback, through which patients can observe their own movements by watching video recordings or using mirrors, has been shown to be effective in correcting posture and improving motor coordination. A study involving individuals who had experienced a stroke demonstrated that combining visual feedback with verbal instructions resulted in significant improvements in gait and balance.

According to Guimarães and Liebano[8], physical therapy interventions using visual and tactile feedback have been effective in improving posture and motor control in these patients, promoting greater stability and motor coordination. The physical therapist's touch helps stimulate proprioceptive receptors, thereby facilitating the recovery of motor control and body awareness.

Combining visual and auditory feedback provides patients with greater awareness of their errors, thus facilitating the necessary adjustments and accurate execution of movements. This statement is further supported by Jiménez-Díaz et al.[25], who conducted a meta-

analysis examining the impact of augmented feedback on motor performance and concluded that interventions involving extrinsic feedback improve motor skill performance in stroke survivors.

Auditory feedback has proven to be an effective tool in post-stroke rehabilitation. Patients receive clear verbal instructions regarding rhythm, speed, and posture, enabling them to make the necessary adjustments during treatment and potentially facilitating faster recovery. Soares[22] states that patients' motor performance can be successfully improved using verbal instructions and sounds to synchronize movements, such as controlling gait rhythm, particularly during the more advanced stages of rehabilitation.

Furthermore, the use of technologies such as biofeedback, which provides real-time information about an individual's muscle activity or posture, has emerged as a promising approach. Cano Porras et al.[10] indicate that technological devices, such as motion sensors and virtual reality platforms, not only support treatment by providing immediate feedback on physical performance but also increase patient motivation by incorporating game-based elements into therapeutic sessions, making the process more participatory and engaging.

Another key aspect identified in the reviewed literature concerns the importance of humanized and individualized physical therapy interventions. The relationship established between the physical therapist and the patient goes beyond the implementation of motor techniques and includes emotional and psychological support, which are essential components of effective rehabilitation. In addition to experiencing physical impairments, individuals who have suffered a stroke often experience emotional disorders, such as anxiety and depression, which may hinder their participation in therapeutic processes[29].

In this regard, the role of the physical therapist as a motivational agent is essential. Alves et al.[30], indicate that a physical therapy approach based on humanized care, in which the professional understands the patient's limitations, provides emotional support, and adapts treatment to individual needs, leads to better therapeutic outcomes. Individualized physical therapy enables patients to feel understood and supported, thereby increasing treatment adherence and strengthening their confidence in the rehabilitation process.

Tocci and Costa[26] in turn, emphasize that humanizing physical therapy care means ensuring that patients receive treatment with dignity, promoting their autonomy and encouraging their active participation in rehabilitation. Studies indicate that patients who feel empowered during treatment are more likely to achieve positive functional outcomes, as trust in the therapist and in the rehabilitation process is strengthened through a relationship based on respect and communication.

Neuroplasticity, which refers to the brain's ability to reorganize itself and establish new neural connections following an injury, is a fundamental process in the rehabilitation of motor functions affected by stroke. The studies reviewed demonstrate that external feedback plays a significant role in promoting neuroplasticity, contributing to synaptic reorganization and the recovery of motor skills[15].

When patients receive external feedback while performing a task, they can correct errors in real time, facilitating the formation of new neural circuits that replace impaired connections. Bastos et al.[12], state that the early introduction of external feedback into treatment enhances neuroplasticity, as frequent exposure to stimuli accelerates the motor relearning process. The application of visual, tactile, and auditory stimuli during the initial rehabilitation phase may lead to more effective recovery of affected functions, particularly in patients with significant motor and sensory limitations.

Motor learning, enhanced by external feedback, is closely associated with successful rehabilitation. According to Fernandes[16], repetitive practice and feedback play a fundamental role in acquiring new motor skills. The author suggests that when patients modify their movements based on the instructions received, they reinforce the neural connections associated with these skills. This highlights the importance of external feedback as a facilitating factor in neuroplasticity and motor learning, particularly among individuals with neurological impairments.

The findings reveal that external factors, such as family support, lifestyle habits, and housing conditions, play an essential role in rehabilitation outcomes. According to Riani and Tutrut[31], individuals living in environments adapted to their physical limitations tend to achieve more effective recovery. Home accessibility and safety are essential factors in promoting patient autonomy and mobility while reducing the risk of falls and other complications.

Furthermore, family support is extremely important because it provides patients with the emotional assistance they need to cope with the challenges of the rehabilitation process. Ferreira et al.[32] highlight that patients who receive continuous assistance from family members and caregivers demonstrate greater treatment adherence and faster progress. Family involvement in rehabilitation may range from accompanying patients to physical therapy sessions to adapting the home environment to facilitate daily activities, such as mobility and personal care.

The findings presented are consistent with the existing literature, indicating that both extrinsic feedback and physical therapy care play essential roles in the rehabilitation of post-stroke patients. By providing sensory information during and after movement execution, extrinsic feedback facilitates the correction of impaired motor patterns, stimulates neuroplasticity, and promotes motor relearning. Humanized care, in turn, creates an environment of trust and respect, which is essential for treatment adherence.

These findings reinforce the need for an integrative therapeutic approach that considers not only motor function but also emotional support and external conditions, such as the home environment and family support, to ensure effective and sustainable recovery.

Discussion

The analysis of the results indicates that extrinsic feedback, by providing external information about patients' motor performance, has a direct impact on improving motor control and balance during the recovery of individuals who have experienced a stroke. This is supported by Chiviacowsky et al.[21], who emphasize that visual feedback is a crucial tool for enhancing motor coordination, as well as assisting in correcting patients' posture and gait. Guimarães and Liebano[8] share this perspective, adding that visual feedback, when combined with tactile feedback, further enhances postural stability and body awareness.

The combination of visual and tactile feedback enables better integration of proprioceptive stimuli, which, according to Guimarães and Liebano[8], facilitates the recovery of motor control in patients with conditions such as hemiparesis. They argue that although tactile feedback is slower due to the complexity of somatosensory processing, it plays an important role when combined with visual feedback, as it enhances proprioceptive integration, allowing greater precision in motor control and accelerating recovery. In contrast, Chiviacowsky et al.[21], advocate the use of visual feedback alone. According to these authors, visual feedback activates the visual cortex, which establishes connections with motor areas responsible for movement execution, enabling patients to identify their errors and immediately correct their posture and gait. This rapid correction facilitates synaptic reorganization in the brain, promoting the recovery of motor control and neuroplasticity.

Bastos et al.[12] reinforce that frequent exposure to visual stimuli significantly contributes to the formation of neural connections, enhancing motor learning. This makes such feedback essential for promoting rapid and precise motor adjustments, which are fundamental in the treatment of patients with stroke-related sequelae.

Furthermore, Jiménez-Diaz et al.[25] emphasize that auditory feedback, provided through verbal instructions from the physical therapist, helps improve movement coordination by assisting patients in adjusting the rhythm and cadence of their actions. They further highlight that extrinsic feedback in motor learning is not limited to the initial stage of recovery. During the associative stage, it helps refine movements by eliminating minor errors and consolidating correct movement patterns. During the autonomous stage, even when patients are able to perform movements more automatically, feedback remains useful for fine adjustments and maintaining motor performance. Thus, extrinsic feedback in its various forms (visual, tactile, and auditory) acts at different levels of learning. It promotes everything from immediate error correction to movement refinement, contributing to motor recovery and accelerating the neuroplasticity process[25].

The concept of neuroplasticity explains the effectiveness of extrinsic feedback. According to Bastos et al.[12], the introduction of external stimuli enhances neural reorganization by promoting the formation of new synapses that compensate for connections impaired by brain injury. This process is extremely important for individuals who have experienced a stroke, since the injury may compromise significant areas of the motor and sensory cortex. In other words, extrinsic feedback provides continuous corrective information, acting as an external stimulus that promotes neuronal reorganization.

According to Zilli et al.[15], neuroplasticity is highly dependent on repetitive practice and continuous movement correction, and feedback plays an essential role in guiding patients toward the correct execution of movements by providing the stimuli required for this reorganization. The results also indicate that the early introduction of these stimuli may increase brain plasticity during the critical recovery period, accelerating the motor learning process[3]. Another relevant aspect is the role of the vestibular system in balance control and how feedback can compensate when this system is impaired. According to Germoglio et al.[3], the vestibular system is responsible for spatial perception and postural balance, functions that are commonly affected in post-stroke patients, making walking difficult and causing frequent falls and postural instability.

The use of technologies such as biofeedback and virtual reality also enhances the effects of extrinsic feedback. According to Cano Porras et al.[10], these technologies provide detailed, real-time information about patients' motor performance, allowing them to make immediate adjustments during physical therapy sessions. Biofeedback, for example, provides a visual representation of physiological variables, such as muscle activation, facilitating more precise movement correction.

Virtual reality and motion sensors offer an interactive experience, making the rehabilitation process more dynamic and engaging for patients. According to Soares[22], the use of this technology increases patient engagement in rehabilitation, making the process less stressful and more enjoyable, which is beneficial for patients who find repetitive exercises discouraging or demotivating. The introduction of these technologies not only improves movement accuracy but also contributes to faster and more effective recovery[12].

The humanization of physical therapy care is also a recurring topic. A humanized therapeutic approach based on empathy and attention to patients' needs is considered to improve therapeutic outcomes. The relationship between the physical therapist and the patient must be built on trust to establish an environment conducive to treatment adherence. Post-stroke patients often face emotional challenges, such as depression and anxiety, which may compromise their involvement in rehabilitation[32].

Tocci and Costa[26] emphasize the importance of this humanized approach, in which physical therapists provide not only technical feedback but also encouragement and motivation. When feedback is delivered positively and in an individualized manner, it increases patient engagement in the rehabilitation process. This is particularly important for patients with emotional difficulties, who often require additional support to remain motivated and committed to treatment.

A comparison between Alves et al.[30] and Tocci and Costa[26] A comparison between Alves et al.[30] and Tocci and

Costa[26] reveals that both studies agree that humanization is fundamental. However, Tocci and Costa[26] expand this concept by incorporating the idea that patient autonomy should be actively promoted, meaning that patients should participate more directly in treatment decisions. This more patient-centered approach may be particularly important for improving motivation and long-term commitment to treatment.

Finally, family support and the home environment are factors that directly affect successful recovery. Riani and Tutrut[31] emphasized that adapting the home environment through the implementation of accessibility measures can promote patient recovery and provide a safe setting for daily activities. Ferreira et al.[32] add that emotional support from family members is equally important, as family involvement in the rehabilitation process may increase patient adherence to treatment.

Conclusion

This study provided an understanding of how extrinsic feedback and physical therapy care play fundamental roles in the rehabilitation of post-stroke patients, directly influencing motor recovery and the neuroplasticity process. The results showed that the use of sensory feedback, whether auditory, visual, or tactile, contributes to the correction of motor patterns, enhances body awareness, and accelerates neural reorganization.

The findings also demonstrated that a humanized and individualized physical therapy approach strengthens the relationship between patients and physical therapists, promoting greater treatment adherence and positively influencing patients' motivational and emotional states.

The use of technology and virtual reality proved promising as motivational and interactive elements in treatment, enhancing patient engagement in the rehabilitation process. Furthermore, external factors, such as family support and home environment conditions, were also identified as essential for effective rehabilitation, promoting autonomy and safety in daily activities.

In summary, this study reaffirms the importance of an integrative physical therapy approach that considers both motor aspects and patients' emotional and social factors. The value of extrinsic feedback and humanized care should be emphasized in physical therapy practice to promote faster and more effective recovery, as well as a better quality of life for individuals who have experienced a stroke.

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