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Evaluation of photobiomodulation as a proposed treatment in post-stroke recovery: A literature review.

Evaluation of photobiomodulation as a proposed treatment for post-stroke recovery: a literature review

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Summary

Stroke is one of the leading causes of morbidity and mortality worldwide, characterized by sudden changes in cerebral blood flow resulting in motor, cognitive, and sensory deficits. Post-stroke rehabilitation requires a multidisciplinary approach focused on functional recovery and the promotion of neuroplasticity through the use of complementary therapeutic resources. In this context, photobiomodulation (PBM) has emerged as a promising adjuvant therapy, acting on cellular processes related to tissue regeneration, inflammatory modulation, and increased mitochondrial energy production. This study is a literature review based on nine studies published between 2014 and 2024 on the application of PBM in the rehabilitation of post-stroke patients. The studies demonstrated positive results regarding the improvement of motor and cognitive function and quality of life, associating the technique with neuroprotective and biostimulating effects. However, methodological heterogeneity was observed among the studies, especially regarding application parameters, highlighting the need for further studies to standardize the application parameters of FBM. It is concluded that this technique represents a safe, low-cost, and potentially effective therapeutic resource, with expanded benefits when integrated into conventional rehabilitation therapies. Its incorporation into public health services can promote a more accessible, interdisciplinary practice centered on patient functionality.

Keywords: Low-level laser therapy. Stroke. Neurological rehabilitation. Alternative therapy.

Abstract

Cerebrovascular accident (CVA) is one of the main causes of morbidity and mortality worldwide, characterized by sudden changes in cerebral blood flow that result in motor, cognitive, and sensory deficits. Post-stroke rehabilitation requires a multidisciplinary approach, aimed at functional recovery and the promotion of neuroplasticity, through the association with complementary therapeutic resources. In this context, photobiomodulation (PBM) has stood out as a promising adjunctive therapy, as it acts on cellular processes related to tissue regeneration, inflammatory modulation, and increased mitochondrial energy production. The present study is a literature review, based on 9 studies published between 2014 and 2024, on the application of PBM in the rehabilitation of post-stroke patients. The studies demonstrated positive results regarding the improvement of motor function, cognitive function, and quality of life, associating the technique with neuroprotective and biostimulant effects. However, methodological heterogeneity was observed among the studies, especially regarding the application parameters, highlighting the need for new research to standardize the application parameters of FBM. It is concluded that this technique represents a safe, low-cost, and potentially effective therapeutic resource, with expanded benefits when integrated with conventional rehabilitation therapies. Its incorporation into public health services can promote a more accessible, interdisciplinary practice centered on the patient's functionality.

Keywords: Low-level laser. stroke. Neurological rehabilitation. Alternative therapy.



Introduction

A stroke (cerebrovascular accident - CVA) is a neurological condition characterized by Sudden interruption of cerebral blood flow, which may result in motor impairments. Cognitive, sensory, and language impairments. It is one of the leading causes of death and Disabilities worldwide represent a significant challenge for public health systems and for the functional rehabilitation of affected individuals (Margarido et al., 2021). Among the subtypes The most common types of stroke are ischemic stroke, resulting from the obstruction of cerebral vessels, and cerebral hemorrhagic stroke. Hemorrhagic, caused by the leakage of blood into the brain tissue. Regardless of In this type of event, the acute event generates significant repercussions in brain function, requiring strategies. rehabilitation methods capable of promoting neuroplasticity and restoring lost functions. (Dumont, 2020).

In recent years, there has been a growing interest in adjuvant therapies that integrate conventional rehabilitation methods, focusing on functional recovery and quality of life. Patients' lives. In this context, photobiomodulation (PBM), a therapeutic modality based on The application of low-intensity red or infrared light has emerged as an alternative. promising (Cozer et al., 2023; Dumont, 2020). The term laser, an acronym for *Light Amplification by Stimulated Emission of Radiation* refers to a device that emits electromagnetic radiation. whose interaction with biological tissues stimulates cellular processes and promotes beneficial effects on health (Dos Reis Coser et al., 2023). FBM acts at wavelengths between 600 and 100 nanometers, a range that allows for effective penetration into tissues, including deep structures such as the central nervous system, stimulating cell regeneration, optimizing mitochondrial metabolism, Improved blood flow and modulation of inflammatory processes (Dos Reis Coser et al., 2023).

Clinical and experimental studies demonstrate that FBM can promote gains in functional mobility, reducing neurological deficits, and acting synergistically with other interventions, such as antioxidant supplementation or static magnetic fields (Dumont, 2020; (Vogel, 2021). Recent integrative reviews indicate that, despite methodological limitations in Based on available studies, FBM shows positive effects in promoting neuroplasticity and in Functional recovery after stroke (Cozer et al., 2023; Santos et al., 2023; Bacelete; Gama, 2023). In addition Furthermore, the integration of FBM into interdisciplinary care models – including physiotherapy, Speech therapy and occupational therapy – reinforces its relevance as a therapeutic resource. complementary, capable of strengthening clinical practices that prioritize patient functionality (Crus & Zanona, 2023; Amaral et al., 2024).

Given this scenario, it becomes necessary to gather, critically analyze, and discuss accordingly. Scientific literature points to the available evidence regarding FBM as an adjunctive therapy in Rehabilitation of post-stroke patients. In this sense, the following question arises, guiding this research: What are the effects of FBM, as reported in the scientific literature, as an alternative therapy in the process? Rehabilitation of post-stroke patients?

2. Theoretical Framework

2.1 Concept and classification of stroke

A stroke is an acute neurological condition resulting from the interruption of blood flow. Cerebral hemorrhage can occur due to either obstruction (ischemia) or rupture (hemorrhage) of a blood vessel. This interruption leads to a deprivation of oxygen and nutrients in the affected areas, resulting in cell death and consequent loss of corresponding neurological functions. The severity of The clinical picture depends on the extent and location of the brain injury, as well as the speed with which the treatment is instituted (Lima et al., 2016).

According to scientific literature, stroke is classified into two main forms: Ischemic and hemorrhagic. The ischemic type accounts for the majority of cases, representing approximately 80% of episodes occur due to the obstruction of a cerebral vessel by thrombi or emboli. As for... The hemorrhagic type, responsible for approximately 20% of cases, results from the rupture of a blood vessel. blood, causing blood to leak into the brain tissue and increasing pressure. Intracranial. In both situations, there is compromised tissue perfusion and consequent damage. neuronal, which can result in motor, cognitive, and sensory deficits (Correia et al., 2018).

Among the main risk factors associated with the development of stroke, the following stand out: Systemic arterial hypertension, diabetes mellitus, dyslipidemias, smoking, alcoholism, Sedentary lifestyle and obesity. In addition, population aging and family history of Cardiovascular diseases are also linked to the increased incidence of this pathology. These These factors, when combined, potentiate endothelial dysfunction and plaque formation. atherosclerotic and hemodynamic instability, mechanisms that contribute directly to the emergence of the cerebrovascular event (Moraes, 2021).

Stroke represents a significant public health problem in Brazil, with 422,638 cases. hospitalizations recorded in the last five years, according to Margarido et al. (2021). Although Although the incidence is higher among men, mortality tends to be higher in women, and both The occurrence and impacts of the disease increase with age.

Furthermore, the increasing prevalence of motor, cognitive, and sensory sequelae makes it necessary to... Significant challenges to health systems and interdisciplinary clinical practice focused on rehabilitation. In addition to the clinical impact, stroke has significant socioeconomic repercussions, since... Neurological sequelae often compromise the autonomy and quality of life of those affected. affected individuals (Margarido et al., 2021).

2.2 Post-stroke rehabilitation processes

Often, the patient requires ongoing monitoring, physiotherapy, Speech therapy, occupational therapy, and long-term rehabilitation generate significant costs. for the health system as well as for the families involved. It is estimated that a large proportion of individuals Those affected exhibit some degree of functional limitation even after treatment, which affects directly impacts their social and labor reintegration (Lopes et al., 2016).

Following a stroke, rehabilitation involves multiple therapeutic approaches aimed at restoring to restore lost functions and promote the patient's functional independence. Among the methods In conventional medicine, physiotherapy plays an essential role in stimulating the recovery of strength. muscular, balance and motor coordination development, contributing to social reintegration and improvement. of quality of life (Rodrigues; Mazzola, 2019).

Speech therapy, in turn, works to rehabilitate language and communication functions. frequently affected after a stroke, enabling significant advances in social interaction and in individual autonomy (Santana; Chun, 2017).

In this context, it is understood that neurological recovery after a stroke is closely related. related to neuroplasticity mechanisms, which correspond to the brain's ability to to reorganize its neural connections in response to stimuli and injuries. This property allows it to intact areas take over compromised functions, enabling motor, cognitive and readaptation. sensorial (Andreoti Borges et al., 2024).

Therapeutic interventions such as physiotherapy, occupational therapy, and cognitive stimulation. They favor this process, enhancing the results of rehabilitation (Andreoti Borges et al., 2024). Neuroplasticity, however, is influenced by factors such as age, intensity, and duration of... In addition to its association with innovative resources such as FBM therapy, brain stimulation does not invasive and the use of immersive technologies. Thus, understanding its mechanisms is fundamental to to optimize rehabilitation protocols and expand the possibilities for functional recovery of individuals affected by stroke (Andreoti Borges et al., 2024).

2.3 Photobiomodulation (PBM)

Despite advances in conventional treatments, limitations still exist in promoting... of full functional recovery, which highlights the need to explore adjuvant therapies with neuroregenerative potential. In this context, FBM emerges as a promising technique, acting in fundamental cellular mechanisms, such as ATP synthesis and the modulation of oxidative stress. and the reduction of local inflammatory responses — factors that can contribute to optimizing the brain plasticity in the post-lesion period (Cozer et al., 2023; Santos et al.; Vogel, 2023).

The relevance of FBM research is reinforced by its applicability in clinical models. and experimental, in addition to the possibility of integration into interdisciplinary therapeutic practices, such as physiotherapy, speech therapy and occupational therapy, strengthening the patient-centered approach. patient functionality (Crus; Zanona, 2023; Amaral et al., 2024; Revista CEFAC, 2021).

2.4 Application protocols and parameters used

FBM is based on the interaction of low-intensity light with biological tissues. According to Kujawa et al. (2014), some studies have indicated that laser exposure in the light range Red blood can intensify the activity of the plasma membrane of cells. FBM exerts its therapeutic effects resulting from the direct interaction of light with intracellular components called chromophores, the main one being cytochrome C oxidase, an enzyme located in the respiratory chain. mitochondrial.

When these chromophores absorb photons from red light sources or Infrared radiation stimulates mitochondrial metabolism and consequently increases synthesis. adenosine triphosphate (ATP), a molecule essential for cell repair and maintenance processes. (Hamblin, 2017; Carvalho et al., 2021).

According to Silva et al. (2022), the frequency of treatment performed three times per One week, with a dose of 4 J/cm², showed as its main result an improvement in mobility. However, according to Silva et al. (2021), applying the treatment five times a week, with A dose of 6 J/cm² resulted in greater stimulation of neuronal plasticity.

In addition to increasing ATP production, light absorption triggers a series of... secondary photophysical and photochemical effects, including the release of nitric oxide (NO), transient increase in reactive oxygen species (ROS) and modulation of intracellular levels calcium. These phenomena activate cell signaling pathways related to proliferation and migration.

and differentiation, favoring a biochemical environment conducive to tissue regeneration and Functional restoration in injured areas (Hamblin, 2017; Yang et al., 2019).

2.5 Therapeutic effects of FBM in post-stroke rehabilitation

From a neurophysiological point of view, FBM is capable of modulating energy metabolism. cerebral, increase local blood flow and reduce oxidative stress, stimulating anti-inflammatory and neuroprotective (Dompe et al., 2020). Studies indicate that this modulation contributes for the recovery of neural circuits, enhancing neuroplasticity and synaptic reorganization. in regions affected by ischemic events, such as stroke (Hamblin, 2016; Saleh et al., 2020).

However, the therapeutic efficacy of FBM depends on precise application parameters. The literature describes a dose-dependent biphasic behavior, in which low light intensities They promote biostimulating effects, while excessive doses can generate inhibitory responses or deleterious. Thus, strict control of variables such as wavelength, energy density, Potency and exposure time are crucial for the safety and effectiveness of the treatment. (Hamblin, 2017; Karu, 2010).

2.6 Material and Method

This study is a literature review aimed at analyzing the scientific evidence available on the application of FBM as a therapeutic approach in recovery of patients affected by stroke. The methodology adopted seeks to gather, select and analyze relevant publications that address the effectiveness, protocols, and effects of the technique in context of neurological rehabilitation.

The search for studies was conducted in the SciELO, PubMed, LILACS, and Google databases. Academically, articles with full texts were selected, without language restrictions. The keywords used were: photobiomodulation, stroke, neuroplasticity. and low-intensity laser.

Articles published between 2013 and 2024, available in full text, were included. presented primary studies or systematic reviews related to the use of FBM in the process. rehabilitation studies for patients in the post-stroke period. Studies from different outlines, provided they were aligned with the proposed theme.

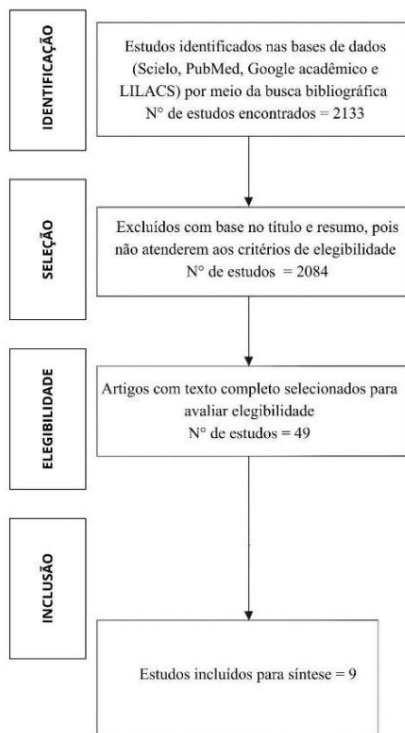
Duplicate materials, articles unavailable in full, and papers were excluded. academic papers such as theses, editorials, letters to the editor, isolated abstracts, and publications that do not They addressed the application of FBM in the post-stroke context.

The selected articles were analyzed through critical reading and categorization. thematic, focusing on mechanisms of action, protocols used, and therapeutic results observed. This approach allowed for a broad understanding of the current landscape of the literature and This allowed for the identification of evidence, gaps, and future perspectives on the use of FBM in neurological rehabilitation.

3. Results and Discussion

This review systematized the findings of several studies that investigated the effects. FBM as a therapeutic method in the rehabilitation of post-stroke patients, as outlined. in Figure 1.

Figure 1 - Flowchart of the study selection process.



Source: The authors, 2025.

A complete reading of the 9 selected articles was carried out, and the main information — authors, The year of publication, journal, title, and objective—these were extracted, organized, and presented in Table 1. follow.

Author and Year	Magazine	Title	Objective
Bacelete et al., 2021.	CEFAC Magazine	Therapeutic effects of photobiomodulation in speech-language pathology clinics: an integrative literature review.	Review studies on the therapeutic effects of photobiomodulation in speech therapy.
Chavantes et al., 2021.	Athenaeum.	Laser and photobiomodulation in rehabilitation and pain: fundamentals and clinical applications.	Discuss the fundamentals and Clinical applications of laser and photobiomodulation in rehabilitation and pain management.
Cozer et al., 2023.	Journal of Neurological Rehabilitation.	Photobiomodulation in post-stroke rehabilitation: a systematic review.	To conduct a systematic review on the use of photobiomodulation in post-stroke rehabilitation.
Dompe et al., 2020.	Journal of Clinical Medicine.	Photobiomodulation – underlying mechanism and clinical applications.	To explore applications of photobiomodulation and its cellular mechanisms.
Dumont, 2020.	Journal of Neurotherapeutics.	Laser therapy and neuroplasticity: mechanisms of functional recovery after stroke.	To discuss how laser therapy promotes neuroplasticity and post-stroke recovery.
Hamblin, 2019.	Photobiomodulation, Photomedicine, and Laser Surgery.	Mechanisms and applications of photobiomodulation therapy in neurology.	Review the mechanisms and applications of photobiomodulation in neurological diseases.
Karu., 2020.	Health Physics.	Photobiology of low-power laser effects.	To investigate the biological effects of low-power laser radiation.
Kujawa et al., 2014.	Lasers in Medical Science.	The effect of near-infrared MLS laser radiation on cell membrane structure and radical generation.	To evaluate the effect of MLS laser radiation on the cell membrane and free radicals.
Santos et al., 2024.	Brazilian Journal of Health Review	The therapeutic potential of photobiomodulation in stroke management: a systematic review.	To analyze the use of photobiomodulation in the rehabilitation of post-stroke patients.

Source: The authors (2025).

The following presents the results of the main research studies that served as the basis for the analysis. This study provides a comparative overview of the effectiveness of photobiomodulation in different clinical contexts.

Table 2. Results of the main research on photobiomodulation.

Author	Result	Conclusion
Bacelete et al.	Most studies have shown positive effects, but with varying methods and few standardized protocols.	FBM is promising, but still requires more research and standardization of parameters.
Chavantes et al.	Laser and FBM reduce inflammation and pain, and stimulate tissue regeneration.	Photobiomodulation is effective, but it requires well-defined protocols.
Cook and al.	FBM improves gait, muscle tone, and functional recovery after stroke.	It can be used as a supplement in the rehabilitation of post-stroke patients.

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Dompe et al.	FBM acts on the mitochondria, increasing ATP and reducing oxidative stress.	It has clinical potential in neurology and pain management, with good safety.
Dumont. Laser	stimulates neuroplasticity and angiogenesis post-stroke.	It can promote functional recovery, but it depends on the correct dosage.
Hamblin	FBM modulates inflammation, apoptosis, and stimulates neural regeneration.	The application in neurology is effective and safe, but still requires clinical studies.
Karu.	Low-power laser activates cytochrome C oxidase and increases ATP.	It scientifically justifies the use of photobiomodulation.
Kujawa et al.	Laser MLS alters the cell membrane and reduces free radicals.	It has biochemical effects that are relevant for rehabilitation.
Santos et al.	It showed improvement in motor functions and neural recovery, but with few studies and varied methods.	The technique shows promise in the treatment of stroke, but requires more standardized research.

Source: The authors (2025).

Analysis of the selected studies revealed favorable evidence regarding the potential.

Therapeutic use of FBM as an auxiliary resource in the rehabilitation of patients affected by stroke. According to Dompe et al. (2020) define FBM as the therapeutic effect caused by light, capable of inducing modulations. photochemical and photophysical factors that influence cellular metabolism. According to Karu (2020), the Low-level laser therapy is one of the most widely used devices for achieving these effects. stimulating mitochondrial bioactivity and tissue repair without causing thermal damage. The findings They indicate significant effects of the technique on neuroplasticity and functional motor recovery. and cognitive, contributing to improved performance and quality of life for patients.

Bacelete and Gama (2021) identified, in their integrative review, that the application of FBM In clinical settings, it promotes tissue repair processes, inflammatory modulation, and analgesia. In addition to stimulating cellular metabolism by increasing mitochondrial activity. These The results reinforce the applicability of the technique in neuromotor and cognitive dysfunctions. highlighting its supporting role in rehabilitation therapies.

Similarly, Chavantes et al. (2021) presented biological foundations and Clinical experts support the use of FBM in rehabilitation and pain management. According to the authors, the light The laser, by interacting with cellular chromophores, triggers photobiological responses that promote neuronal reorganization, edema reduction, and improved tissue perfusion — essential factors for post-stroke recovery

Cozer and Souza (2023), in a systematic review focused specifically on rehabilitation Post-stroke, they reported positive results from FBM regarding the recovery of motor function, speech and from the coordination, with a significant improvement in the patients' quality of life. However, the authors They emphasize the need for standardization of therapeutic parameters, such as dose, frequency, and duration. application, to optimize clinical results.

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Dompe et al. (2020) and Hamblin (2019) describe the cellular and molecular mechanisms of FBM, demonstrating that red and infrared light acts on cytochrome C oxidase, promoting increased ATP production, oxygenation, and cell signaling. These effects contribute to synaptic plasticity and the regeneration of neural circuits damaged by stroke.

Dumont (2020) adds to this by demonstrating that FBM induces processes of cortical neuroplasticity, stimulating the recruitment of adjacent brain areas and compensatory factors, associated with the functional improvement observed in patients during rehabilitation. Karu (2020), in turn, reinforces the photobiological basis of the technique when discussing the mitochondrial biostimulation induced by low-power lasers, highlighting the importance of adequate energy density to avoid inhibitory effects.

In the experimental field, Kujawa et al. (2014) analyzed the effects of MLS laser on near-infrared, observing positive structural changes in cell membranes and significant reduction in the generation of free radicals. These results indicate antioxidant action and FBM's protective effect on neuronal tissues vulnerable to oxidative stress resulting from stroke.

Santos et al. (2024), in a systematic review, confirm the therapeutic potential of FBM in stroke management, with emphasis on improving motor and cognitive functions and reducing sequelae. However, they point out that there is still... neurological benefits and accelerated functional recovery. Methodological heterogeneity among the studies highlights the importance of more comprehensive clinical trials. However, they point out that there is still... controlled and standardized.

In summary, the results analyzed demonstrate that FBM is a therapeutic strategy. Despite the evidence promising, with neuroprotective, anti-inflammatory, and bioenergetic effects. Despite the positive aspects, the literature still highlights the need for standardization of clinical protocols and... validated assessment instruments, ensuring greater reliability and comparability between studies. Integrating FBM into multidisciplinary approaches can enhance results and to consolidate its effectiveness in post-stroke rehabilitation.

Final Considerations

Stroke is a major public health problem due to its high incidence and mortality. and its impact on quality of life. Functional recovery depends on rehabilitation. multidisciplinary and continuous, in which neuroplasticity plays a fundamental role by enabling Brain reorganization. In addition to conventional therapies such as physiotherapy and speech therapy, FBM It emerges as a promising complementary method, capable of stimulating ATP production and reducing... Reduce oxidative stress and promote tissue regeneration and neural plasticity in post-stroke patients.



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The findings of this review demonstrate that FBM, when associated with protocols of Conventional rehabilitation can enhance motor, cognitive, and sensory restoration, in addition to contribute to improving the quality of life of affected individuals. It was observed, among the The studies analyzed showed considerable variation in the application protocols of photobiomodulation. especially regarding the parameters used, which highlights the lack of standardization. methodological. This heterogeneity reinforces the importance of conducting future studies with more consistent by Designs, larger samples, and extended follow-up, in order to to consolidate the technique as an evidence-based therapeutic practice.

From a social and public health perspective, the inclusion of FBM in rehabilitation protocols, especially within the scope of the Unified Health System (SUS), is configured as a A promising strategy to expand access to effective, safe, and low-cost therapies. FBM demonstrates potential as an adjunctive therapeutic intervention in post-stroke rehabilitation, supported by scientific evidence and its clinical applicability. However, strengthening research and Standardization of application protocols is fundamental to consolidating their use as a practice. based on evidence, contributing to a more integrated, efficient and patient-centered rehabilitation. functionality and quality of life for patients.

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