DERLEME / REVIEW

Post-Earthquake Spinal Cord Injury: Role of Physiotherapy and Rehabilitation

Deprem Sonrası Omurilik Yaralanması: Fizyoterapi ve Rehabilitasyonun Rolü

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Abstract

This review examines the crucial role of physiotherapy and rehabilitation in the management of post-earthquake spinal cord injuries (SCI). After an earthquake, patients with SCI require specialized and intensive rehabilitation programs to promote recovery, prevent complications, and enhance their quality of life. This article reviews the pathophysiology of post-earthquake SCI, the various clinical and functional assessments used to evaluate severity, and the different treatment options available including pharmacotherapy, surgical interventions, and rehabilitation. This review discusses the challenges and barriers faced by patients and healthcare providers, the expected outcomes and prognosis for patients, and the key findings and recommendations for future research and practice. The review emphasizes the importance of an individualized physiotherapy and rehabilitation approach to the management of post-earthquake SCI.

Keywords: Earthquake, spinal cord injury, physiotherapy, rehabilitation, assessment.

Öz

Bu derleme, deprem sonrası oluşan omurilik yaralanmalarının tedavisinde fizyoterapi ve rehabilitasyonun kritik rolünü incelemektedir. Bir depremden sonra, omurilik yaralanması olan hastalar, iyileşmeyi desteklemek, komplikasyonları önlemek ve yaşam kalitelerini artırmak için özel ve yoğun rehabilitasyon programlarına ihtiyaç duyarlar. Bu makale, deprem sonrası omurilik yaralanmalarının patofizyolojisini, şiddetini değerlendirmek için kullanılan çeşitli klinik ve fonksiyonel değerlendirmeleri ve farmakoterapi, cerrahi müdahaleler ve rehabilitasyon dahil olmak üzere mevcut farklı tedavi seçeneklerini gözden geçirmektedir. Bu derlemede, hastaların ve sağlık hizmeti sağlayıcılarının karşılaştığı zorluklar ve engelleri hastalar için beklenen sonuçlar ve prognoz ve gelecekteki araştırma ve uygulamalar için önemli bulgular ve öneriler tartışılmaktadır. Derleme, deprem sonrası oluşan omurilik yaralanmalarının yönetiminde bireyselleştirilmiş bir fizyoterapi ve rehabilitasyon yaklaşımının önemini vurgulamaktadır.

Anahtar Kelimeler: Deprem, omurilik yaralanması, fizyoterapi, rehabilitasyon, değerlendirme.

1. Introduction

Natural disasters such as earthquakes are associated with significant morbidity and mortality, often resulting in long-term disabilities that require specialized rehabilitation services (1). One of the most devastating consequences of earthquakes is spinal cord injury (SCI), which can have profound physical, psychological, and social impacts on individuals and their families (2, 3). SCI is a complex condition that requires a comprehensive and coordinated approach to management, which includes early medical intervention, pharmacotherapy, surgical interventions, and specialized rehabilitation services (4). Physiotherapy and rehabilitation are essential components of the rehabilitation process for patients with SCI, and play a critical role in maximizing functional outcomes, enhancing the quality of life, and reducing long-term disability.

Despite the importance of physiotherapy and rehabilitation in the management of post-earthquake SCI, access to specialized rehabilitation services is often limited in low- and middle-income countries where earthquakes are more common (5). The lack of adequate resources and infrastructure, as well as the high costs associated with specialized rehabilitation, can create significant barriers to the delivery of effective and comprehensive rehabilitation services (6).

Therefore, this article aims to review the current literature on the role of physiotherapy and rehabilitation in the management of post-earthquake SCI. The article will provide an overview of the pathophysiology of SCI, the various clinical and functional assessments used to evaluate severity, and the different treatment options available including pharmacotherapy, surgical interventions, and

rehabilitation. It will also explore the challenges and barriers faced by patients and healthcare providers in the management of post-earthquake SCI, the expected outcomes and prognosis for patients, and the key findings and recommendations for future research and practice. The article will emphasize the importance of an individualized physiotherapy and rehabilitation approach to the management of post-earthquake SCI.

1.1. Pathophysiology of SCI After an Earthquake

The pathophysiology of SCI after an earthquake requires a comprehensive understanding to design effective prevention, diagnostic, and therapeutic strategies that can improve the outcomes of patients with SCI. The pathophysiology of SCI is complex and involves a series of cascading events that can result in permanent damage to the spinal cord tissue, leading to impaired motor, sensory, and autonomic functions.

The mechanisms of SCI after an earthquake are diverse and can vary from direct trauma to the spinal cord to secondary damage resulting from ischemia, inflammation, and oxidative stress. The sudden acceleration and deceleration forces generated by the earthquake and/or being hit by falling debris while sitting or standing can cause vertebral fractures, dislocations, and ligamentous injuries, leading to compression, laceration, and contusion of the spinal cord tissue (7, 8). In addition, rescuers, the majority of whom are unskilled local earthquake survivors, rush to save as many people as they can, frequently unaware of the significance of spinal immobilization in those suffering from back and neck injuries. Usually, injured victims are dragged, tugged, and carried away from the rubble without taking spinal immobilization into account (9).

The disruption of the spinal cord blood supply can also contribute to the pathophysiology of SCI after an earthquake. The compromised blood flow can lead to ischemia, which triggers a cascade of events, including the release of glutamate, calcium influx, and the activation of inflammatory pathways, leading to neuronal apoptosis and necrosis (7). In addition to acute injury, SCI after an earthquake can also lead to chronic degeneration and tissue remodeling. The progressive loss of neurons, glia, and myelin can result in the formation of cysts, cavities, and scar tissue, further impairing neural transmission and functional recovery (10).

1.2. Assessment and Evaluation

After an earthquake, timely and accurate clinical and functional assessments are essential to evaluate the severity and extent of SCI. Several assessments have been developed to diagnose the type of SCI, the level of injury, and the degree of neurological impairment.

1.2.1. Clinical Assessments

The clinical assessments of SCI include a physical examination, imaging studies, and neurological evaluations. The physical examination involves assessing the level of consciousness, vital signs, and the presence of fractures, dislocations, and ligamentous injuries. Imaging studies, including radiography, computed tomography (CT), and magnetic resonance imaging (MRI), can diagnose the type and location of the SCI (11). Radiography can identify fractures and dislocations of the vertebral column, while CT can provide detailed images of bony structures and soft tissue injuries. MRI is the preferred imaging modality for the evaluation of SCI, as it can visualize the spinal cord and surrounding structures and detect the presence of edema, hemorrhage, and contusion (12). Electrophysiological tests, such as electromyography (EMG) and nerve conduction studies, can provide objective measures of nerve and muscle function and evaluate the severity and extent of SCI after an earthquake. They can also differentiate between complete and incomplete injuries, as well as provide information on the potential for recovery (13). The neurological evaluations involve assessing the level and completeness of the SCI, based on the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) (14).

1.2.2. Functional Assessments

Assessing the severity and extent of SCI after an earthquake is not only crucial for guiding effective rehabilitation interventions by identifying key problems and setting realistic goals, but also for predicting outcomes. The functional assessments of SCI include measures of motor, sensory, and autonomic functions.

The motor assessments involve testing the strength, tone, and reflexes of the muscles, using scales such as the Medical Research Council (MRC) scale or the American Spinal Injury Association (ASIA) Impairment Scale (15, 16). The sensory assessments involve testing the perception of touch, pinprick, and vibration, using the sensory score of the ASIA Impairment Scale (16). The autonomic assessments involve testing the function of the bladder, bowel, and sexual organs, using scales such as the Autonomic Standards Assessment Form (17). There are also various tools, such as the Spinal Cord Independence Measure (SCIM), Functional Independence Measure (FIM), Walking Index for SCI, and Barthel Index (BI), which assess the patient's ability to perform self-care, mobility, and social interactions.

Although assessments are very important in physiotherapy and rehabilitation, there is no widespread international agreement on what the ideal battery of assessment for patients with SCI should include. However, the task force of the Spinal Cord Injury Group of the American Physical Therapy Association published outcome measures recommendations for people with SCI. Readers interested in learning more about these outcome measures are directed to the official website (https://www.neuropt.org/practice-resources/neurology-section-outcome-measures-recommendations/spinal-cord-injury).

1.3. Treatment Options

The management of post-earthquake SCIs involves a multidisciplinary approach, including pharmacotherapy, surgical interventions, stem cell therapy, and rehabilitation.

Pharmacotherapy is an essential component of the management of post-earthquake SCI. Medications used for SCI management include corticosteroids, which have been shown to improve motor and sensory recovery (18). Additionally, antispasmodic medications, such as baclofen and tizanidine, are used to manage spasticity in patients with SCI (19, 20).

Surgical interventions are often required for patients with post-earthquake SCI. These interventions include decompressive laminectomy, which is used to relieve spinal cord compression caused by fractures and dislocations, and spinal stabilization procedures, which aim to stabilize the spine and prevent further injury (21, 22). Other surgical interventions, such as nerve grafting and spinal cord stimulators, may be considered in select cases (23, 24).

Despite numerous advancements in medicine, there are presently no successful regenerative therapies. However, a promising treatment choice for SCI is stem cell therapy. Studies have shown that stem cell therapy may promote neuronal regeneration and functional recovery in animal models of the SCI (25). While human studies are limited, stem cell therapy is being investigated as a potential treatment for post-earthquake SCI.

Rehabilitation is a crucial component of the management of post-earthquake SCI. This includes physiotherapy, occupational therapy, and speech therapy. Rehabilitation aims to optimize the patient's functional status, prevent secondary complications, and improve the overall quality of life.

1.4. Physiotherapy and Rehabilitation

Neuroplasticity, defined as the brain's ability to reorganize and adapt to changes in the environment, plays a crucial role in the recovery of function after SCI. Physiotherapy and rehabilitation techniques should aim to harness the principles of neuroplasticity to promote functional recovery. To achieve this goal, instead of passive treatment options, methods with the active participation of the patient that follows the motor learning principles should be performed.

1.4.1. Early Mobilization

Early mobilization is a key aspect of rehabilitation following post-earthquake SCI. It is important to begin mobilization as soon as possible to prevent secondary complications and improve outcomes by promoting neuroplasticity (26, 27). Early mobilization can also help to reduce spasticity and prevent contractures.

As soon as the patient with SCI is in a stable medical condition after the accident, the mobilization should begin. Depending on whether the patient sustained additional injuries as a result of the earthquake or later acquired and/or had medical or respiratory complications, the starting time of the mobilization can range from a few days to several weeks. The stability of the spine is clearly a priority to start the mobilization. On the other hand, maintaining blood pressure, circulation, respiration, bladder drainage, bowel care, and body temperature are just a few of the many other factors that must be taken into consideration before early mobilization.

1.4.2. Respiratory Management

One of the most frequent medical consequences seen among people with SCI is respiratory dysfunction which is the main factor in mortality and decreased quality of life. Respiratory complications are prevalent in 67% of people with SCI in the acute stage (28). People with upper levels of SCI have more respiratory dysfunction. The multiple system involvement after an earthquake (such as trauma to the thorax) would increase the rate of respiratory dysfunction.

During the acute phase of the SCI, monitoring for diaphragmatic function, pulse oximetry, and arterial gasometer is very important. The ventilation parameters are chosen by the multidisciplinary medical team to accommodate the patient's unique respiratory requirements. A physiotherapist plays a critical role, especially in the weaning and post-extubating periods.

Proper positioning is critical for improving breathing patterns and improving ventilation. A patient with an SCI may need to rely on accessory muscles to breathe, which may include trunk muscle recruitment for inspiration and expiration. To improve breathing and enable the use of accessory muscles when the trunk muscles are too weak to support upright sitting, appropriate wheelchair seating, and positioning are necessary (29).

Due to expiratory muscle weakness, a patient with an SCI may have difficulty mobilizing secretions. Secretion mobilization interventions would include postural drainage, suctioning, coughing techniques, vibrations and percussion, mechanical exsufflation and insufflation, and specialized breathing techniques such as the active cycle of breathing and autogenic drainage.

1.4.3. Management of the Contractures

Contractures are a frequent issue following SCI. Passive range of motion and stretching exercises are commonly applied to prevent and treat contractures in patients with SCI. However, there is no strong evidence about the effectiveness of these interventions, especially due to the heterogeneity in the studies and also the short follow-up periods in the studies. For an effective treatment, high doses and over long periods of time are needed. Therefore, range of motion and stretching exercises, and positioning should be a daily routine of a patient. However, such interventions can be time-consuming for a physiotherapist. Caregiver education is an important component of a rehabilitation program to overcome this issue. In addition, with a good assessment, physiotherapists should target the riskiest parts of the body. For example, a patient with C6 involvement most probably develops elbow flexion contractures due to the paralysis of the triceps muscles. These contractures prevent the patient from lifting his or her body weight with the upper limbs, and thus the quality of life will be affected. In this scenario, the physiotherapist should focus on these body parts.

1.4.4. Strengthening Exercises

The most visible disability preventing people with SCI from doing motor tasks is muscle weakness. As a result, strengthening exercises are another essential component of physiotherapy and rehabilitation in the management of the post-earthquake SCI (30). These exercises aim to increase muscle strength and endurance, improve cardiovascular fitness, and prevent muscle atrophy.

The neurologically intact muscles of a patient with SCI respond the same as a healthy person's muscles. As a result, a conventional progressive resistance training program that gradually and properly increases the load can be used (31). However, it is important to remember that it is better to use such a program within the context of a functional skill to enhance neuroplasticity. On the other hand, it is not clear

whether partially paralyzed muscles directly affected by SCI can improve. However, some studies suggest that there are increases in the strength of partially paralyzed muscles over time (31). Therefore, there is no concrete evidence of how strengthening exercises should be. There are many studies that investigated different types of strengthening exercises and/or in combination with electrical stimulation. However, the results are conflicting. According to the expert opinion, "the most sensible approach may involve a combination of progressive resistance training interspersed with the repetitive practice of functional tasks involving low loads and high repetitions. It may also be reasonable to administer electrical stimulation in combination with high resistance and maximal voluntary effort." (31).

1.4.5. Functional Training

Important functional motor activities for people with SCI include walking, transferring, pushing a wheelchair, and other upper limbs-related activities. Improving these activities is crucial for a better quality of life. During functional training, motor learning principles should be applied.

Motor learning is a process that involves acquiring and refining skills related to physical movement. It is an essential part of human development and is critical for patients with SCI to improve their skills in the activities of daily living. The principles of motor learning are a set of guidelines and concepts that describe how individuals acquire and refine motor skills. There are several principles of motor learning, including:

1.Practice: Practice is essential for the acquisition and refinement of motor skills. The amount and frequency of practice can affect the speed and extent of motor learning.

2.Feedback: Feedback is critical for motor learning because it provides information about the quality of movement and guides the learner toward the correct movement pattern.

3.Transfer: Transfer refers to the ability to apply a learned skill to new situations or contexts.

4.Variability: Variability in practice can enhance learning by promoting the development of generalized motor programs that can be adapted to different situations.

5.Attention: The degree to which a learner focuses on the movement during practice can affect learning. In comparison to an internal focus of attention, which involves focusing on the action itself, an external focus of attention, which involves focusing on the movement's effect, is more efficient.

These principles have been identified through research and practice and are important to consider when designing effective motor learning programs. By understanding and applying these principles, patients with SCI can improve their performance and adapt to changing environments or conditions.

Gait training is a crucial component of rehabilitation in patients with post-earthquake SCI who are able to walk. Gait training aims to improve gait pattern, balance, and overall mobility.

In order to enhance gait in patients with SCI, traditional physiotherapy techniques like hands-on therapy, overground gait training, and strengthening and stretching exercises are frequently used. In addition to these methods, treadmill training including, body-weight-supported treadmill training, functional electrical stimulation, and robotic-assisted gait training are potential methods used in patients with SCI (32). Body-weight-supported and robotic-assisted treadmill training involves the use of a harness to support the patient's weight while walking on a treadmill and/or robotic components to support extremities, promoting gait training and functional recovery. Functional electrical stimulation uses electrical currents to stimulate the nerves that innervate the muscles, resulting in muscle contraction. Functional electrical stimulation can be used to improve muscle strength, reduce spasticity, and promote functional recovery.

A recent meta-analysis including 17 randomized controlled trials showed that acute-phase robotic-assisted gait training significantly improves the velocity, distance, and Walking Index for SCI score compared to conventional physiotherapy in patients with incomplete SCI (32). Functional electrical stimulation has the greatest likelihood of being the best intervention for velocity and distance. Functional electrical stimulation is followed in terms of efficacy by the treadmill, functional electrical stimulation plus treadmill, robotic-assisted gait training, and conventional physiotherapy.

Assistive devices, such as wheelchairs and orthoses, are often required for patients with post-earthquake SCI. These devices can improve mobility and independence, reduce secondary complications, and improve the overall quality of life. In rehabilitation programs, it is important to select and/or design these devices specific to the patient, and to teach the use of the devices.

1.5. Challenges and Barriers

Despite the recent advancements in the field, there are still several challenges and barriers faced by patients and healthcare providers in the management of post-earthquake SCI.

Access to healthcare is a significant challenge faced by patients with post-earthquake SCI. In many low- and middle-income countries, healthcare infrastructure and resources are limited, and the availability of specialized care for post-earthquake SCI is often inadequate (33). This can result in delayed diagnosis and treatment, which can have a negative impact on patient outcomes.

Post-earthquake SCI can have a significant socioeconomic impact on patients and their families. The cost of treatment, rehabilitation, and assistive devices can be a major financial burden for patients, especially in low- and middle-income countries (34, 35). This can lead to a reduced quality of life and limited access to care.

Patients with post-earthquake SCI often face significant psychosocial challenges, such as depression, anxiety, and social isolation (36, 37). These issues can have a negative impact on patient outcomes and can make it difficult for healthcare providers to manage their care effectively.

Rehabilitation is a crucial aspect of the management of post-earthquake SCI. However, there are several challenges and barriers to effective rehabilitation. For example, limited availability of specialized rehabilitation services, lack of

trained personnel, and inadequate resources can all have a negative impact on patient outcomes (6). To overcome this problem, telerehabilitation can be a promising tool.

Cultural beliefs and attitudes can also be a barrier to the effective management of post-earthquake SCI. In some cultures, disability is stigmatized, and patients may face discrimination and social exclusion (38). This can make it difficult for patients to access care and can lead to reduced quality of life, especially in the chronic stage of SCI.

1.6. Outcomes and Prognosis

Patients with complete sensory-motor lesions have a very limited chance of walking at follow-up, and if they can, their walking ability is typically very limited. People with less severe lesions have better healing prospects for walking. Patients with an ASIA Impairment Scale B lesion may regain their ability to walk, particularly if their clinical picture indicates a less severe spinal cord involvement (light touch and pinprick conservation = some sparing of the spinothalamic and posterior columns tracts = higher likelihood of cortico-spinal tracts preservation). Finally, patients with ASIA Impairment Scale C lesions can walk, especially the younger ones (39). According to one study, factors such as being older, having a higher body mass index, having a pre-existing condition, having the ASIA Impairment Scale grades A and B, having a lower ASIA Motor Score, and experiencing medical complications are all significantly linked to having less functional independence (40).

The time between injury and treatment is a crucial factor that can influence recovery outcomes. Early intervention with pharmacotherapy and rehabilitation is associated with better recovery outcomes, as it can prevent secondary complications and promote neuroplasticity.

Socioeconomic factors, such as education, income, and social support, can also influence recovery outcomes. Patients with higher levels of socioeconomic status tend to have better recovery outcomes compared to patients with lower levels of these factors (41, 42).

2. Conclusion and Recommendations

The management of post-earthquake SCI is a complex process that requires a multidisciplinary approach. Physiotherapy and rehabilitation play a crucial role in the management of these injuries, as they can promote recovery, prevent complications, and enhance the quality of life. This review provides a very rough overview of SCI rehabilitation. It should be noted that there are many other assessment and treatment approaches that are not discussed in this review.

Intensive and individualized physiotherapy and rehabilitation programs can improve motor function, independence, and quality of life in patients with post-earthquake SCI. Early intervention with pharmacotherapy and rehabilitation is associated with better recovery outcomes, as it can prevent secondary complications and promote neuroplasticity. A lack of specialized healthcare services and resources, particularly in low- and middle-income countries, can hinder the management of post-earthquake SCI and limit recovery outcomes.

Future research should focus on developing and evaluating innovative and cost-effective rehabilitation interventions for post-earthquake SCI, particularly in low- and middle-income countries. Telerehabilitation should be further explored as a viable alternative to traditional in-person rehabilitation services in the context of natural disasters, particularly in resource-limited settings. Collaborative efforts between healthcare providers, policymakers, and community organizations are necessary to ensure the availability and accessibility of specialized healthcare services and resources for patients with post-earthquake SCI. Future research should also focus on identifying and addressing the socioeconomic and cultural factors that can hinder the management of post-earthquake SCI and limit recovery outcomes.

3. Contribution to the Field

Since Türkiye is located in the seismic zone, earthquakes occur frequently, and these earthquakes have severe consequences, such as post-earthquake SCI. This review will provide an overview of post-earthquake SCI rehabilitation for the injured people in the Türkiye–Syria earthquakes of 2023 were back-to-back earthquakes of magnitudes 7.8 and 7.7 that occurred in Kahramanmaraş at 4:17 and 13:24 local time of Türkiye on February 6, 2023, and following future earthquakes.

Acknowledgement

I send my condolences to the families and friends of people who lost their lives after the earthquakes measuring 7.7 and 7.6 on the Richter scale that occurred on February 6, 2023, causing fatal destruction and casualties in Türkiye and Syria. I also wish a speedy recovery to the injured people. I hope that this review will make a contribution to the recovery of injured people.

Conflict of Interest

There is no financial or other conflict of interest related to the study.

Author Contribution

Idea/Concept: TK**; Design:** TK**; Control/Supervision:** TK**; Sources and Fundings: -; Materials: -; Data Collection and/or Processing: -; Analysis and/or Interpretation: -; Literature Review:** TK**; Writing the Article:** TK**; Critical Review:** TK**.**

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