Effects of Pre-Surgery Physiotherapy on Walking Ability and Lower Extremity Strength in Spinal Cord Injury Patients: An Experimental Study

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Abstract

The research investigated how pre-surgical physiotherapy affects walking abilities and strength measurements in individuals who suffer from Spinal Cord Injury (SCI). A randomized controlled trial consisting of 100 participants separated their participants into two equal groups for treatment and monitoring purposes. Assessments of walking ability were made using the 10-meter walk test, and lower limb strength was evaluated through isokinetic dynamometry. Patients reported their muscle tone, range of motion and quality of life alongside the primary outcomes. The data showed that participants who underwent pre-surgery physiotherapy treatments reached significantly superior results in mobility and strength and better wellbeing than participants in the control group. The research data proves that pre-surgical physiotherapy belongs to standard rehabilitation plans for patients with spinal cord injuries. Apart from improving physical abilities, the intervention

delivered positive advantages that enhanced quality of life outcomes for participants. Research needs to continue studying both the extended advantages and functional gain durability after SCI in addition to developing customized preoperative rehabilitation treatments for people who have spinal cord injuries.

Keywords: Spinal Cord Injury, Pre-surgery Physiotherapy, Walking Ability, Lower Extremity Strength, Randomized Controlled Trial, Quality of Life, Rehabilitation

Introduction

A spinal cord injury (SCI) occurs when trauma or disease damages the spinal cord, thus interrupting normal nervous tissue functioning (Ahuja et al., 2017). The nature of the damage done to the spinal cord determines whether someone will permanently or temporarily lose their motor skills, sensory awareness, and autonomic control functions (Somers & Bender-Burnett, 2024). The spinal cord is located in the vertebral column and transmits vital brain-to-body signals to control motor functions, sensations, and automatic body mechanisms (Barker, 2024). A spinal cord injury disrupts the natural processes, resulting in different levels of bodily impairment (Perrouin-Verbe et al., 2021).

The following part delivers a comprehensive breakdown of spinal cord injury by defining its origins, describing its different forms and consequences, and discussing existing treatment alternatives.

Causes of Spinal Cord Injury

Trauma injuries generate the most SCI cases but follow diseases and medical conditions as secondary causes of spinal cord damage. Both treatment success and injury prevention benefit from knowing the different causes of such injuries (Patek & Stewart, 2023).

Traumatic Causes: The spinal cord suffers traumatic injuries by way of violent impacts that harm the spine structure. These are often caused by:

Motor Vehicle Accidents (MVAs): Motor Vehicle Accidents (MVAs) remain the principal cause of Spinal Cord Injury worldwide, accounting for 35-40% of all SCI cases. Motor vehicle activities and motorcycle and truck accidents simultaneously cause spinal cord compression by fracturing and dislocating spine structures (Etha, 2022).

Falls: Further, among elderly people, falls are a significant cause of spinal cord injuries, so persons with osteoporosis and weak bones embrace elevated risk levels (Biz et al., 2024).

Sports Injuries: Football, rugby, and diving are high-risk sports that frequently result in spinal cord injuries in athletes. Objectionable incidents during sports activities commonly result in spinal stretch (hyperextension), spine twist (hyperflexion), or blunt impact to the spine (Farah et al., 2022).

Violence and Gunshot Wounds: The spinal cord gets damaged through violent incidents like stabbings or shootings, which creates serious neurological damage to the body (Sede di Grosseto, 2022).

Workplace Injuries: Occupational accidents, which occur primarily in construction sites together with industrial workplaces, end up causing traumatic SCI (Kamardeen & Hasan, 2023).

Non-Traumatic Causes: Several medical conditions apart from traumatic injuries serve as non-traumatic factors that develop SCI. These include:

Degenerative Diseases: The spinal canal becomes compressed through degenerative

diseases that include osteoarthritis, disc degeneration, and spinal stenosis because these conditions cause spinal cord and nerve pressure (Diwan & Melrose, 2023).

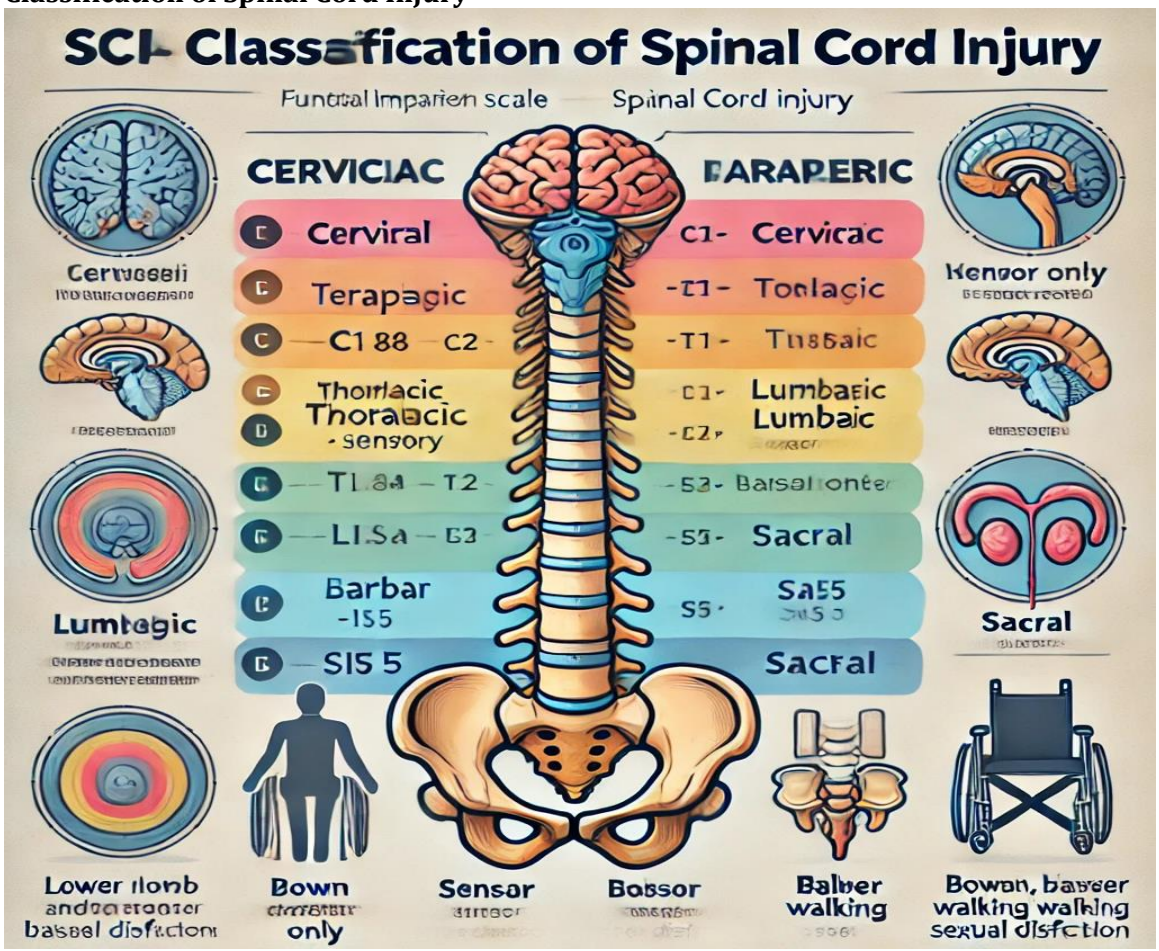
Tumors: Bronchiole tumors and benign and cancerous growths can appear inside or near the spinal cord, generating pressure throughout the cord that produces functional restrictions (Stier et al., 2025).

Infections: Meningitis or spinal abscesses can severely damage spinal cord cells (Jiang et al., 2023).

Vascular Disorders: Stroke, along with spinal cord ischemia, is one of several vascular disorders that cause spinal cord damage by blocking essential blood flow to the spinal cord (Jin et al., 2021).

Congenital Conditions: SCI sometimes develops as an abnormality in the development of the spine or spinal cord (Rupp et al., 2021).

Classification of Spinal Cord Injury



The identification of SCI occurs by examining the degree of tissue dysfunction and the impact on the spinal cord region (Huet et al., 2023). The area of spinal cord injury determines the level, and how much body function remains below the site of damage defines the degree.

SCI Levels: Different spinal cord sections determine the assessment regions based on vertebrae positions. These include:

Cervical (C1-C8): The neck region. When affected, the cervical spinal cord region generates tetraplegia (quadriplegia), affecting upper and lower body functions (Alhazmi et al., 2024).

Thoracic (T1-T12): The upper and mid-back region. SCIs originating from this region result in paraplegia, which damages both the lower limb functions and the trunk (Mneimneh, 2021).

Lumbar (L1-L5): The lower back region. SCI involves mostly lower limb dysfunction and control problems with the bladder in this spinal area (Rupp, 2021).

Sacral (S1-S5): The lowest part of the spinal cord. Persons sustaining injuries at this level demonstrate diminished control over walking ability and bowel and bladder, respectively, as well as sexual function (Niemi-Nikkola, 2021).

Degree of SCI: The American Spinal Injury Association (ASIA) Impairment Scale (AIS) is a

standard method for classifying the extent of spinal cord injuries into four categories (Biering-Sørensen et al., 2021).

AIS A (Complete): At AIS level A, no sensory or motor ability exists in sacral segments S4-S5 (Hsieh & Gibbs, 2025).

AIS B (Sensory Incomplete): In AIS B (Sensory Incomplete), the nervous system maintains sensory perception while motor abilities stop functioning below the damaged area (Howland et al., 2023).

AIS C (Motor Incomplete): SCI patients under type C show motor recovery, yet most essential muscle operations beneath the affected area lack sufficient strength (Leszczyńska & Huber, 2023).

AIS D (Motor Incomplete): Patients with AIS D (Motor Incomplete) retain motor ability because their key muscle groups below the injury level show strength higher than three points on the muscle strength chart (Kirshblum et al., 2025).

AIS E (Normal): Full recovery of motor and sensory function (Kirshblum et al., 2021).

Symptoms and Functional Impairments

Various symptoms of spinal cord injuries develop based on how high the injury occurred and its extent. Paralysis affects the entire body section or causes only mild weakness in patients, depending on the level of injury.

Loss of Sensation: SCI patients develop sensory deficits beneath their injury zone, affecting their sense of touch and pain, numeric perception, and temperature sensitivity. The lack of sensation after an SCI creates an unsafe condition because patients cannot identify hazardous situations or changes in temperature (Rosner et al., 2021).

SCI causes paralysis or limb weakness at a level that defines the primary symptom

Motor Function Loss: The complete impairment affects both upper and lower limbs in tetraplegia, but individuals with paraplegia experience disability in their lower limbs alone (Kirshblum et al., 2022).

Autonomic Dysfunctions: Third among autonomic dysfunction causes resulting from SCI are:

Blood Pressure Regulation: Blood pressure regulation suffers due to autonomic dysfunction, which creates either low or high blood pressure episodes (hypotension and hypertension) (Karim et al., 2023).

Bowel and Bladder Dysfunction: The loss of bowel and bladder control becomes common after spinal cord injury because spinal cord injuries lead to incontinence issues (Kuris et al., 2022).

Sexual Dysfunction: People with SCI typically develop sexual dysfunction, while its severity depends on the extent of spinal cord damage (Di Bello et al., 2022).

Respiratory Problems: Impaired cervical region functioning may prevent proper breathing, necessitating mechanical ventilation. Patients who sustain injuries at the highest areas of their cervical region will need placement on a ventilator for breathing (Melesse et al., 2024).

Pain: Chronic pain affects many SCI patients by producing neuropathic pain from spinal cord and nerve pathway damage (Cui et al., 2023).

Treatment and Rehabilitation

SCI remains a permanent condition; however, modern medical treatments and rehabilitation methods enhance many patients' quality of life (Nistor-Cseppento et al., 2022).

Acute Treatment: After spinal cord injury, patients need immediate professional medical intervention as the first response during acute stages; acute treatment focuses on three primary objectives, which include injury prevention while also handling possible problems and achieving patient stability. This may include:

Immobilization: Medical personnel utilize spinal boards and collars to stop body movement, reducing patient harm (Kolli et al., 2024).

Surgery: The patient requires surgical intervention to eliminate bone fragments as well as spine stabilization operations together with spinal cord decompression procedures (Porche et al., 2024).

Medication: Patients receive methylprednisolone steroids as a medical treatment to decrease spinal cord swelling and reduce inflammation (Canseco et al., 2024).

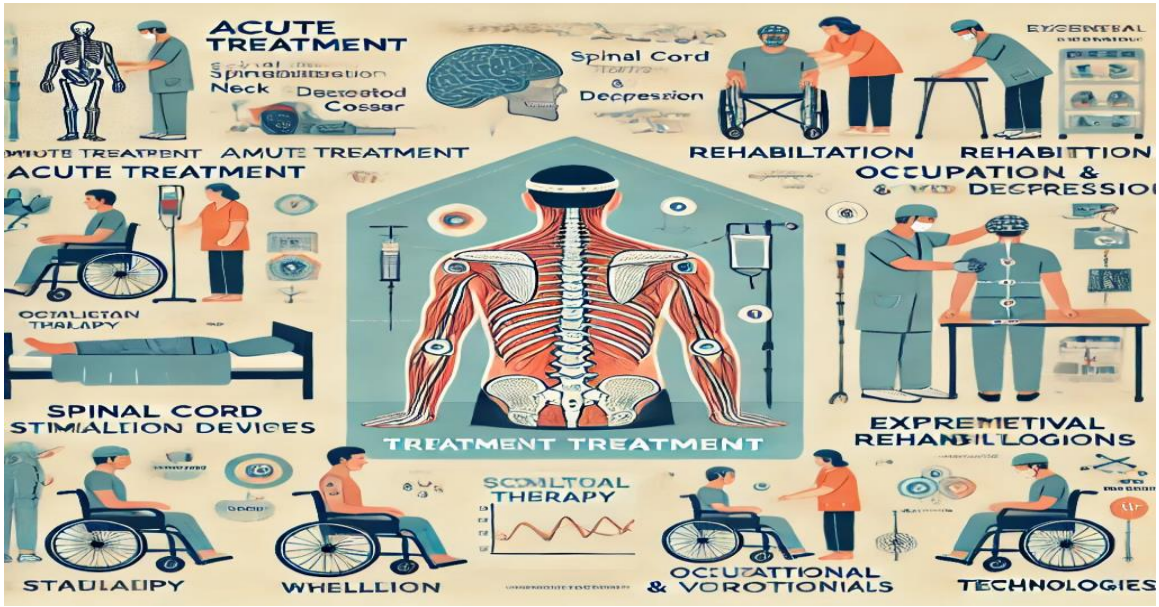
Rehabilitation: Recovery from spinal cord injury demands complete rehabilitation because it serves as a vital step toward SCI recovery. Medical professionals utilize physical therapy with occupational therapy and further rehabilitation techniques to achieve maximal independence as they help patients develop their functionality (Güngör, 2024). Rehabilitation may include:

Physical Therapy: Physical Therapy utilizes strength-building exercises with movement classes to make patients independent (Baldania & Baladaniya, 2024).

Occupational Therapy: Occupational Therapists assist patients in managing daily activities by creating plans that use assistive tools and devices (Li & Xu, 2021).

Vocational Rehabilitation: Vocational Rehabilitation programs help patients resume their jobs or explore different career options that fit their capabilities (Murray et al., 2022).

Experimental Treatments and Technologies: Stem cell therapy and neuroprosthetics, as well as spinal cord stimulation executions, are part of the experimental treatments and technologies that demonstrate the potential to recover abandoned functions (Nizamis et al., 2021).



Impact of SCI on Quality of Life

The consequences of spinal cord injury create overwhelming changes throughout a person's entire life (Budd et al., 2022). The disability creates extensive psychological as well as social side effects, which are equally challenging to handle. Patients may experience:

Emotional and Psychological Effects: People with spinal cord injuries typically develop depression with anxiety symptoms that lead to posttraumatic stress disorder (PTSD) (Kuiper et al., 2021). People face numerous difficulties when they try to adapt to lost functional abilities.

SCI frequently leads to lifetime disability because it creates economic challenges as well as family and social relationship adjustments alongside social separation.

Literature Review

Current Treatment Options for Spinal Cord Injury (SCI): SCI is a substantial problem in medical practice that produces substantial consequences for people who suffer this injury (Zhang et al., 2021). The main treatment targets of SCI focus on maintaining injury stability and preventing spinal damage while controlling symptoms and achieving healing potential. Multiple therapeutic methods make up the treatment of this condition, including acute care, surgical procedures, rehabilitation, and extended care services (Karunarathna et al., 2024). The following section elaborates on the existing treatment methods by examining surgical approaches with rehabilitation programs and the early implementation of physiotherapy.

Surgery in Spinal Cord Injury: Surgery is a primary response treatment during the acute phase of SCI. Various treatments employ such procedures to protect the spinal cord while lessening spinal tissue pressure (Fiani et al., 2021). Additionally, this stabilizes the spinal structures to further minimize damage. Medical procedures exist within two categories that depend on injury types and patient health status.

Types of Surgery for SCI:

Decompression Surgery:

Purpose: The surgery eliminates pressure on spinal nerves and cord matter caused by vertebrae fractures, herniated discs, and other medical conditions (Saifee et al., 2024).

Procedure: The surgeon operates to remove bone fragments together with herniated disc material and compress spinal cord obstructions. The most successful cases of this technique occur when a person suffers a traumatic spinal cord injury with mechanical compression (Wang et al., 2024).

Effectiveness: SCU cases benefit most from decompression treatment, which, when done promptly, helps prevent additional harm to the nervous system.

Spinal Fusion:

Purpose: The surgical purpose is to maintain spinal stability in patients suffering from SCI with vertebral instability or fractures (Husssin et al., 2023).

Procedure: During this surgical operation, surgeons implement metal rods combined with screws or plates to stabilize the vertebrae, thus blocking additional movement, which worsens the injury (Daun & Davis, 2023).

Effectiveness: The surgical intervention delivers two benefits: reducing spinal deformities and speeding up post-operative patient recovery. Many surgical teams choose to perform

both decompression and the fusion procedure (Drossopoulos et al., 2024).

Spinal Cord Repair and Regeneration:

Purpose: The goal of experimental procedures includes repairing and regenerating tissue that has sustained damage to the spinal cord (Roolfs et al., 2022).

Approaches: Medical practitioners use three approaches for spinal cord treatment, including stem cell therapies, nerve graft applications, and biological agents that promote neural tissue regeneration. These experimental techniques have demonstrated potential as recovery methods for SCI patients during their ongoing development phase (Zipser et al., 2022).

Effectiveness: Spinal cord regeneration methods show promise, but research has not established their capability to restore full functional function in human patients. Scientific research centers are conducting ongoing trials to evaluate their performance.

Internal Fixation and Stabilization:

Purpose: The main goal of this treatment method is to immobilize the spine after breaks or dislocations occur so spinal cord damage does not increase (Fiani et al., 2021).

Procedure: Medical implants composed of metals such as screws and plates, and rods are inserted during this procedure to strengthen fractured spine bones (Litak et al., 2022).

Effectiveness: Patient recovery benefits from this surgical approach because it stops spinal instability from worsening.

Timing of Surgery: Surgical operations for spinal cord injury must be performed appropriately since this timing directly affects the therapeutic results. Medical intervention should be initiated as soon as possible within the 24 to 72-hour period to prevent additional neurological tissue harm. Evidence shows that performing decompression procedures shortly after the spinal cord injury delivers better results because it decreases paralysis levels and enhances feeling sensations (Tabarestani et al., 2022).

Surgical Risks: Surgical procedures that save lives and enhance the results involve these three primary risks (Osagwu et al., 2024):

- Infection
- Bleeding
- Nerve damage
- Post-surgical complications such as blood clots or delayed healing

Post-Surgical Considerations: Users require multiple forms of medical support after their surgery, which consists of:

Pain Management: Surgical patients require strong painkiller medications such as opioids together with local anesthetics to properly manage their postoperative pain (Hyland et al., 2021).

Recovery Time: The recovery duration depends completely on which specific surgery was performed and may extend from weeks to months. Starting physical therapy immediately after surgery helps patients achieve better healing outcomes (Bednar, 2023).

Rehabilitation in Spinal Cord Injury

SCI recovery requires rehabilitation as its fundamental component. The process entails different therapies to manage mobility, strength, and independence development, combining physical therapy with occupational therapy and numerous therapeutic practices (Ratri, 2023).

Goals of Rehabilitation:

Maximizing Functional Independence: Functional independence is the main target of rehabilitation because nurses aim to help patients regain essential daily functions for self-care activities such as dressing, bathing, and eating independently (Dubuc & Beresford, 2021).

Improving Quality of Life: Improving the quality of life of SCI patients is one key goal because these individuals commonly deal with mental difficulties and emotional challenges. Counseling, group therapy, and rehabilitation services help people manage their life challenges and develop improved mental health (Ponzano et al., 2024).

Preventing Complications: Through appropriate rehabilitation, professionals prevent patients from developing secondary conditions, including pressure ulcers, contractures, and respiratory issues (Buyruk et al., 2022).

Types of Rehabilitation:

Physical Therapy (PT):

Focus: The key objective in this setting is to develop stronger muscles while enhancing flexibility and improving balance and coordination.

Techniques: Physical therapy uses different exercises to build muscle strength alongside stretching programs to prevent contractures. It also trains patients through wheelchair use and assistive device walking programs (Scheel-Sailer et al., 2021).

Effectiveness: Physical therapy demonstrates its effectiveness as an intervention that enhances the functional independence of SCI patients, especially for those individuals who maintain some neurological preservation following their injury (Sutor et al., 2022).

Modalities: The rehabilitation practice of electrical and functional electrical stimulation (FES) involves assisting patients with limited motor function in contracting their muscles (Kralj & Bajd, 2022).

Occupational Therapy (OT):

Focus: OT aims to help patients learn practical daily functions, including personal bathing and dressing routines, culinary standards, and job-related performance (Dreiling, 2022).

Techniques: Occupational therapists' training enables patients to learn about adaptive tools, such as wheelchairs and prosthetics, and assistive technology to boost their independence (Oladele et al., 2021).

Effectiveness: Occupational therapy assists patients through its effective approach, strengthening their quality of life by teaching refined motor skills and allowing them to adapt to daily tasks.

Vocational Rehabilitation:

Focus: This assistance's central goal involves helping patients resume employment or enroll in job training.

Techniques: The techniques that achieve this goal include vocational training, counseling, and employment placement support.

Effectiveness: The rehabilitation programs for SCI patients enable them to earn an income through working for financial autonomy while regaining social roles (McClure & Leah, 2021).

Long-Term Rehabilitation: The recovery journey through rehabilitation lasts an extensive period beyond standard healing duration. It involves:

Ongoing Physical Therapy: Ongoing Physical Therapy employs exercises that build strength

to stop muscle atrophy from harming the patient (Huang et al., 2022).

Psychological Support: Therapeutic counseling exists for patients who need help adjusting to their changed lives with medical challenges.

Home and Community Reintegration: Support systems and home modifications help people engage in daily activities after discharge.

Challenges in SCI Rehabilitation: Several obstacles remain given successful SCI rehabilitation recovery despite its proven effectiveness (Tian et al., 2023):

Limited Access to Rehabilitation Services: There is a shortage of top-quality rehabilitation facilities, mainly in places lacking financial resources and remote communities.

Cost: The cost of SCI rehabilitation tends to exceed what insurance and government programs provide fully.

Psychosocial Impact: SCI patients need major psychological assistance when integrating into life with their condition since they commonly experience depression together with anxiety and face social isolation.

Early Intervention Strategies: Physiotherapy

Physical therapy, known as physiotherapy, is vital for recovering from spinal cord injuries during the early stages of an injury. Patients' functional outcomes improve substantially when they begin physiotherapy immediately, and this approach also lowers the chance of complications and helps their bodies recover better (Cordero et al., 2022).

Importance of Early Physiotherapy:

Preventing Muscle Atrophy: Muscle wasting occurs because immobilization leads to the progressive loss of muscle tissue. Physiotherapy intervention during the early stages enables patients to preserve their muscle strength while maintaining muscle mass.

Improving Circulation: Immobilization creates poor blood circulation, which results in blood clots. Physiotherapy enhances blood circulation and decreases the risk of developing deep vein thrombosis (DVT).

Maintaining Range of Motion: Early exercises stop the development of contractures that restrict muscle movement and tendon extension, limiting functional ability and movement.

Physiotherapy Techniques:

Passive Range of Motion (PROM) Exercises: Therapists perform Passive Range of Motion (PROM) exercises on patients who cannot move to stop their joints from stiffness and promote blood circulation (Hesbach, 2024).

Active Range of Motion (AROM) Exercises: When patients return to strength and mobility abilities, Active Range of Motion exercises should become part of the treatment approach.

Strengthening Exercises: Injured individuals with incomplete damage need strengthening exercises to sustain and build muscle strength.

Balance and Coordination Training: Balance coordination training benefits patients who plan to use wheelchairs by developing their posture stability and weight transfer skills.

Benefits of Physiotherapy:

Improved Recovery: The early use of physiotherapy therapy helps patients heal faster through direct time reduction mechanisms, which work best for patients with a chance at recovery (Krishna et al., 2024).

Enhanced Functionality: Physiotherapy delivered in the early stages enhances motor capability while improving the posture control system and enabling better mobility function.

Prevention of Secondary Conditions: Implementing effective physiotherapy decreases the risk of pressure sores, respiratory issues, and other secondary complications that affect SCI patients.

Role of Physiotherapy in Neuroplasticity: Neuroplasticity, a brain function, enables the brain to restructure neural networks through new neural connections. This neurological process is facilitated through Physiotherapy techniques like Functional Electrical Stimulation (FES). When FES activates muscles through electrical signals, it triggers nerve pathfinding pathways to generate possible benefits for recovery and enhanced muscle functions (Afreen et al., 2021).

Challenges of Physiotherapy in SCI:

Patient Motivation: The mental health difficulties experienced by SCI patients create barriers to their participation in physical therapy treatment (Razzaghi et al., 2023).

Access to Resources: None of all patients possess equal availability to specialized physiotherapist care or rehabilitation facilities.

Financial Constraints: Renewing physical therapy treatment after SCI proves costly because of its high expense, particularly when rehabilitation extends beyond a standard period.

Pre-Surgery Physiotherapy for Spinal Cord Injury (SCI)

Treating Spinal Cord Injury(SCI) with pre-surgery physiotherapy is a vital component that functions best in the acute period after the injury (Prins et al., 2024). This treatment has ongoing benefits during SCI management, impacting recovery results, long-term mobility, and patient quality of life. Different stages of pre-surgery physiotherapy build patient readiness for surgical operations through strength improvement and flexibility promotion while stopping complications to minimize patient health decline (Moore, 2023).

The following parts address pre-surgical physical therapy care for SCI patients by examining its essential roles, approach methods, and proven effectiveness in treatment outcomes.

Importance of Pre-Surgery Physiotherapy

The main purpose of pre-surgery physiotherapy is to enhance the physical state of SCI patients before their surgical procedure (Kumar & Chawla, 2023). The surgical intervention demonstrates crucial significance by optimizing results and facilitating a better recovery among patients with restricted mobility or severe functional impairment (Jain et al., 2023).

Goals of Pre-Surgery Physiotherapy

The main objectives of pre-operative physiotherapy involve:

Preventing Muscle Atrophy: Cases involving motor impairments among SCI patients demonstrate a susceptibility toward losing muscle mass because of their inactive state (Dobkin, 2021). The key goal of physiotherapy treatment is to stop or minimize muscle degeneration while increasing muscle activation and blood flow.

Improving Circulation and Respiratory Function: Early implementation of physical therapy allows improved blood movement throughout the body while minimizing the risks of deep vein thrombosis (DVT) formation. The respiratory system benefits from this approach because it helps increase chest mobility and prevents pneumonia and other pulmonary complications (Hillegass et al., 2022).

Maintaining Joint Flexibility: Restricted movement in SCI patients increases the threat of joint contractures. Physiotherapy can preserve joint mobility and avoid muscle tightness,

stiffness, and complications (Lam et al., 2022).

Improving Postural Control: SCI patients, particularly those with incomplete injuries, need improved postural control as a fundamental treatment. Extending the patient's ability to maintain proper posture and stability enables better success during surgical recovery (Noamani et al., 2021).

Enhancing Psychological Readiness: Physiotherapy rehabilitation seeks to boost a patient's psychological status through independent-focused exercises and wellness goals to enhance total wellbeing.

Timing of Pre-Surgery Physiotherapy

The timing for starting physiotherapy treatment should be right after injury onset and extend even before surgical intervention occurs. Early hospital intervention during the first two days assists patients in developing stronger muscles while increasing flexibility and reducing the risk of health issues, including pneumonia, pressure sores, and deep vein thrombosis. Patients who suffer cervical and thoracic SCI require prompt physiotherapy intervention because these injuries lead to elevated risks for complications that affect respiratory muscles (Campbell et al., 2022).

Physiotherapy Techniques and Approaches

Before surgery, physiotherapists employ multiple treatment methods to strengthen their patients while improving flexibility functions and overall mobility in SCI patients. Pregnant women receive treatment methods that account for their medical conditions, injury severity, and the scheduled surgical plan (Sakaguchi et al., 2022).

Passive Range of Motion (PROM) Exercises

Purpose: SCI patients who cannot move their limbs because of paralysis benefit from PROM exercises by assisting a therapist who performs joint and muscle range of motion movements. Joint flexibility stays intact through this intervention technique, so contractures are avoided (Biswas, 2023).

Benefits: PROM exercises benefit patients' post-surgical mobility by helping eliminate muscle stiffness and prevent tissue adhesions while keeping joints mobile.

Active Range of Motion (AROM) Exercises

Purpose: The AROM therapy involves patients continuing their limb movements under their power through their active range of motion when they have maintained some muscle capabilities. These exercises aim to increase the muscles' strength and the coordination of movements (Taye, 2024).

Benefits: AROM exercises have two major advantages: they protect muscles from wasting while improving tonal regulation. These exercises also enhance the coordination and synchronization of limb movement, which is essential for surgical rehabilitation recovery.

Strengthening Exercises

Purpose: Strengthening exercises' main objective is to activate active, functional muscles. The treatment includes three types of exercises: isometric contractions alongside resistance training exercises and functional electrical stimulation (FES) to activate muscles that cannot contract naturally (Schumann et al., 2022).

Benefits: Strengthening exercises improve muscle tone, enhance strength capabilities, and protect against muscle wasting caused by disuse. They also prepare the body for surgery-related physical requirements and recovery after medical treatment.

Functional Electrical Stimulation (FES)

Purpose: FES achieves its purpose through electrical stimulation of affected muscles, producing contractions that activate muscle activity of paralyzed or weakened regions. The application of FES provides exceptional benefits to patients who have experienced complete SCI because voluntary muscle activation is unavailable to them (Faruki, 2023).

Benefits: FES benefits include enhanced blood flow with concurrent muscle prevention of deterioration and sustained muscle state. The treatment activates nerve paths to enhance neuroplasticity, which is one of its benefits.

Breathing and Respiratory Exercises

Purpose: The main objective for SCI patients with cervical injuries is to improve their respiratory functions. Physiotherapists help patients improve their lung capacity and respiratory function through breathing exercises and chest physiotherapy techniques (Hasnakipour et al., 2025).

Benefits: These exercises protect the respiratory system while improving oxygen circulation and minimizing the incidence of pneumonia, which frequently affects SCI patients.

Postural Exercises and Sitting Balance Training

Purpose: Maintaining body posture is a fundamental need among patients with Spinal Cord Injuries. Upright sitting position, along with maintained posture, is an essential objective for pre-surgery physiotherapy rehabilitation. Postural exercises enable patients to achieve proper spinal alignment while developing their weight-shifting abilities (Carayannopoulos et al., 2024).

Benefits: Postoperative rehabilitation benefits from improved sitting balance because patients develop the necessary skills for using wheelchairs and prosthetic devices after surgery.

Psychosocial Support and Education

Purpose: Physiotherapy serves as an essential treatment for the emotional and psychological problems that commonly affect patients with Spinal Cord Injury. Physiotherapists should include preoperative education about injuries combined with goalsetting and mental health support in their planning (Schultz et al., 2022).

Benefits: The treatment outcome heavily relies on the patient's psychological preparedness to recover. Well-defined clinical targets, alongside therapeutic support from physiotherapists, assist patients in emotional recovery, which results in better rehabilitation results.

Benefits of Pre-Surgery Physiotherapy in SCI Patients

Implementing pre-surgical physical therapy brings extended advantages to SCI patients because it positively affects their surgical recuperation process and boosts their quality of life outcomes in the long term (Picariello et al., 2025).

Improved Post-Surgical Recovery

When patients receive pre-surgical physiotherapy treatment, their bodies acquire stronger resilience against surgical trauma, allowing them to recover more quickly. Patients who start physiotherapy for spinal surgery benefit from better post-surgical healing outcomes because their body condition remains improved throughout the process (Calverley, 2024).

Decreased Risk of Complications

Early initiation of physiotherapy therapy cuts down the chance of developing painful

secondary complications such as deep vein thrombosis (DVT), pressure ulcers, muscle contractures, and respiratory infections. Physiotherapy treatments help SCI patients by enhancing blood flow, flexibility, and respiratory function, thus reducing their common health challenges (Linck & Boissonnault, 2024).

Preservation of Function

Patients with incomplete spinal cord injuries benefit from pre-surgical physiotherapy, which helps sustain their functional ability, especially in areas associated with strength and motion. In this phase, patients perform exercises and techniques to maintain their neuromuscular functioning, improving their surgical recovery possibilities (CASE, 2025).

Enhanced Psychological Readiness

Successful rehabilitation depends heavily on patients' proper physical and mental surgery preparation. Preoperative physiotherapy enables SCI patients to take charge of their health condition while decreasing their anxiety to accept therapy positively (Al-Asiri, 2024).

Challenges of Pre-Surgery Physiotherapy in SCI Patients

SCI treatment encounters multiple obstacles regarding the application of pre-surgical physiotherapy benefits.

Accessibility

The availability of trained physiotherapist services and rehabilitation centers remains restricted in locations with minimal resources. The essential healthcare services remain beyond patients' reach because they cannot afford them or face location access problems (Barth et al., 2021).

Psychological Barriers

The emotional stress experienced by SCI patients who deal with depression together with anxiety and trauma makes it hard to complete their physiotherapy exercises. Treating these obstacles requires physical recuperative methods and psychological treatment (Silva Guerrero et al., 2022).

Financial Constraints

The costs of physiotherapy treatments are high, which limits the available insurance benefits. Financial difficulties stop numerous SCI patients from getting enough preoperative rehabilitation services.

Patient Motivation

The task of sustaining patient willingness toward physiotherapy treatment becomes significantly hard for people who have severe or complete SCI. A rehabilitation program succeeds when the therapist dedicates their involvement to patient encouragement and motivation (Barrett & Finlay, 2022).

Problem Statement

SCI exists among the most serious debilitating conditions since it severely diminishes the quality of life of those who experience this condition. This condition results in the loss of motor, sensory, and autonomic functions, which consequently causes major disability. SCI recovery methods primarily rely on surgery and rehabilitation treatment, but the specific effects of pre-surgery physiotherapy on recovery potential need more investigation. The effectiveness of pre-surgical physiotherapy to lessen SCI sequelae while setting surgical recovery foundations remained uncertain for postoperative walking progress, lower limb strength development, and general functional improvement.

The scientific evidence demonstrating physiotherapy's success in treating neurological conditions fails to establish the clinical value of pre-surgical treatment for SCI patients because this approach did not receive sufficient research or implementation in medical settings. Medical approaches primarily centered on surgical procedures combined with postoperative rehabilitation efforts but lacked proper research about early intervention methods throughout the preoperative phase. SCI patients lacked standardization in determining the most suitable physiotherapy treatments during the pre-surgical period.

The lack of research on pre-surgery physiotherapy for SCI patients led to the necessity of conducting investigations regarding its therapeutic effects. The research evaluated how this intervention changed walking abilities, lower extremity strength, and surgical outcome functions after surgical procedures. The study of pre-surgical physiotherapy treatments enables essential knowledge development to create better treatment plans for SCI patients because it examines complication reduction, improved surgical results, and extended rehabilitation outcomes.

Objectives of the Study

1. The research measured pre-surgery physical therapy's effects on walking ability for patients with Spinal Cord Injury.
2. An evaluation of lower extremity strength changes occurs due to pre-surgical physiotherapy treatment.
3. The evaluation of pre-surgery physiotherapy to measure extended recovery advantages after surgical procedures.

Null Hypotheses

1. Pre-surgery physiotherapy does not significantly affect walking ability in Spinal Cord Injury (SCI) patients.
2. Pre-surgery physiotherapy does not significantly change lower extremity strength in patients with SCI.
3. Pre-surgery physiotherapy does not provide extended recovery advantages following surgical procedures in patients with SCI.

Experimental Research Design

Randomized Controlled Trial (RCT): The investigation employed a randomized controlled trial (RCT) experimental design to study the results between two SCI patient groups.

1) **Treatment Group (Pre-Surgery Physiotherapy):** Patients in the Treatment Group underwent pre-surgical physiotherapy as their intervention.
2) **Control Group (No Physiotherapy):** Patients who failed to obtain any pre-surgical physiotherapy treatment formed the group without treatment.

Study Timeframe:

The research investigation lasted from January 1 through January 7, 2025. During this period, treatment for the intervention group was implemented, and results were assessed before and after the intervention to evaluate walking ability and lower extremity strength modifications.

Table 1 Study Timeframe

no	Period	Date Range	Activities
1	Pre-Intervention	Before January 1, 2025	Initial assessments of walking ability and lower extremity strength.
2	Intervention	January 1 - 7,	Physiotherapy intervention for the treatment

		2025	group.
3	Post-Intervention	After January 7, 2025	Post-intervention assessments of walking ability and strength.

The research followed three successive stages: pre-intervention and post-intervention. During the Pre-Intervention period, the research protocol collected data regarding walking capacity and lower limb strength measurements from all individuals before January 1, 2025. The targeted physiotherapy program began during the Intervention phase on January 1–7, 2025, for the treatment group and included strength, balance, and mobility exercises. Data collection for walking ability and strength changes took place in the Post-Intervention period starting from January 7, 2025, to assess the treatment group results against those of controls, thus establishing the effectiveness of physiotherapy intervention.

Table 2 Pre-Surgery Physiotherapy Intervention

no	Intervention Aspect	Details
1	Physiotherapy Program	6-week pre-surgery physiotherapy regimen focusing on strengthening lower extremities, improving flexibility, and enhancing mobility.
2	Duration	6 weeks
3	Focus Areas	Strengthening lower extremities, improving flexibility, and enhancing mobility.
4	Exercises	Strength exercises (e.g., leg presses, squats), balance, and gait training.

SCI patients received a 6-week pre-surgical physical therapy program to improve their physical capabilities before surgery. The program focused on building muscle strength in the lower extremities, developing flexibility, and improving total mobility. The therapy plan included organized physiotherapy sessions that performed strength training through leg presses, squats, balance tasks, and gait practice. The exercise selection included muscle group-specific movements designed to empower patients for walking and functional activities, improving their operational outcome during post-surgical recovery.

Table 3 Outcome Measures

no	Outcome Type	Measure	Details
1	Primary Outcome	Walking ability	Measured using the 10-meter Walk Test or Functional Ambulation Category (FAC).
2	Secondary Outcome	Lower extremity strength	Assessed using the Isokinetic Dynamometer for knee and hip muscles.
3	Secondary Outcome	Muscle tone and range of motion	Other measures include muscle tone and range of motion.
4	Secondary Outcome	Patient-reported outcomes (e.g., pain levels, quality of life)	Includes patient-reported outcomes such as pain levels and quality of life.

The research measured the efficacy of pre-surgical physiotherapy in SCI patients by determining main and supporting outcomes. The main outcome involved a walking ability assessment using a 10-meter Walk Test and Functional Ambulation Category tools for tracking gait abilities. The Isokinetic Dynamometer served as a tool to analyze lower extremity strength by focusing on the strength evaluation of knee and hip muscles. Secondary outcome measures involved testing muscle tone and determining how well the joints could move to understand muscular ability and nervous system reactions. Patient-reported outcomes included pain evaluation and quality of life measurements, which provided subjective assessments of both intervention effects and extensive patient wellness outcomes.

Table 4 Data Collection

no	Data Collection Phase	Details
1	Pre-Intervention	Baseline walking ability and lower extremity strength measurements were taken for all participants.
2	Post-Intervention	Post-intervention data was taken after 6 weeks of physiotherapy for the treatment group.
3	Follow-up	Follow-up data taken 3 months after surgery to assess long-term benefits.

Table 5 Statistical Analysis

no	Analysis Type	Details
1	Descriptive Statistics	Means, standard deviations for demographic variables.
2	Inferential Statistics	Independent t-tests to compare pre-and post-intervention results between groups.
3	Inferential Statistics	ANOVA will evaluate group differences in strength and walking ability changes.

Pre-Intervention (Before January 1, 2025):

The first assessments were performed to measure the baseline walking ability alongside the lower extremity strength of every participant in this phase. The baseline measurements served for future reference to analyze modifications brought by physiotherapy treatment. The assessments functioned to determine how participants performed functionally at the beginning of the study without intervening treatment.

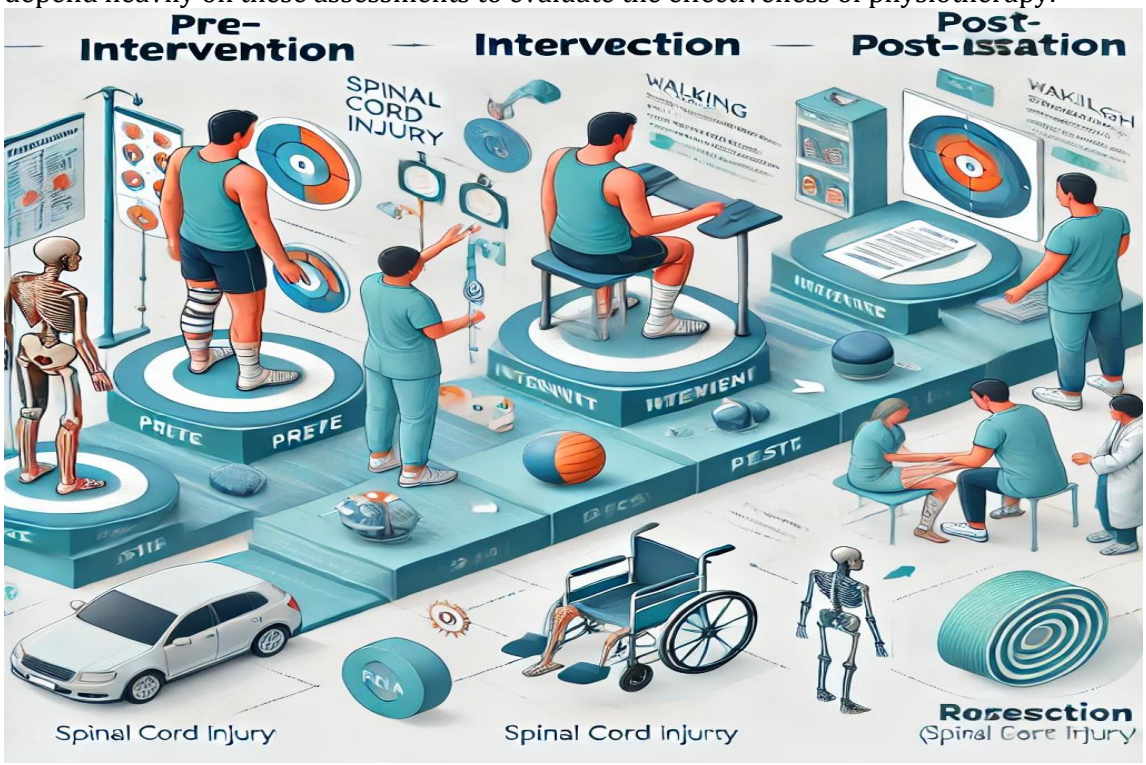
Intervention (January 1 - 7, 2025):

Members of the treatment group received a one-week pre-surgical physiotherapy period while this stage was active. The physical therapy approach emphasized improving walking capability, expanding lower body strength, protecting against muscle wasting, and preventing joint stiffening problems. The primary goal of the intervention was to optimize surgery readiness and improve post-surgical recovery results for the participants.

Post-Intervention (After January 7, 2025):

After finishing physiotherapy, patients underwent additional assessments to document their walking ability and lower extremity strength. The pre-surgery physiotherapy evaluation success rate was determined by analyzing results from post-intervention measures against pre-intervention data points. Long-term functional surgery recovery assessment results

depend heavily on these assessments to evaluate the effectiveness of physiotherapy.



Purpose of the RCT:

The research method allowed direct outcome comparison between pre-surgery physiotherapy effects on SCI patients since participants were distributed randomly between two study groups. The methodological approach acted as a tool to separate and properly evaluate the therapy effects without letting outside factors interfere with the findings.

Outcome Measures:

A pair of standardized assessments, the 10-meter Walk Test and Isokinetic dynamic Dynamometer, for muscle strength testing, measured the walking ability and lower extremity strength points before and after the intervention.

Participants

Inclusion Criteria:

Adult SCI Patients (18-65): The study included adult participants aged 18 to 65 diagnosed with Spinal Cord Injury (SCI) and motor or sensory deficits due to their injury.

Patients Scheduled for Surgery: Medical staff only admitted patients planning surgery due to SCI complications featuring either spinal stabilization or decompression procedures. Participants received pre-surgery physiotherapy treatment because the requirements included all participants in this phase of their care plan.

Exclusion Criteria:

Contraindications to Physiotherapy: The study excluded patients who had uncontrolled hypertension, heart failure, or other medical conditions that would make physiotherapy dangerous for their health. For safety reasons, all subjects needed protection from harm

when receiving physiotherapy treatment.

One of the eligibility barriers for participation in this study is the presence of severe neurological conditions and orthopedic problems that occur together.

Coexisting Severe Neurological or Orthopedic Conditions: The research excluded patients who had severe multiple sclerosis, advanced Parkinson's disease, or orthopedic disabilities, which would disrupt the physiotherapy procedures. The external conditions included in the participants could contaminate the research findings since they complicate the assessment of the effects of preoperative therapy.

Sample Size:

Total Sample Size: A total of one hundred participants were distributed into two equal groups for this study.

Treatment Group: Fifty patients received preoperative physical therapy education as part of the treatment group.

Control Group: The 50 participants in the Control Group did not undergo pre-surgery physiotherapy.

Table 6 Inclusion and Exclusion Criteria

n	Criteria Type	Criteria
1	Inclusion	Adult SCI patients (age 18-65) with diagnosed motor or sensory deficits.
2	Inclusion	Patients scheduled for surgery (e.g., spinal stabilization, decompression).
3	Exclusion	Patients with contraindications to physiotherapy (e.g., severe cardiovascular issues).
4	Exclusion	Those with coexisting severe neurological or orthopedic conditions.

Table 7 Sample Size

Group	Sample Size
Treatment Group	50
Control Group	50

1.29. Results of the Study

Table 8 Demographic Data

Demographic Characteristic	Details
Age	Mean: 45 years, Range: 18-65
Gender	Male: 60, Female: 40
SCI Severity	Mild: 30, Moderate: 40, Severe: 30
SCI Type	Cervical: 20, Thoracic: 40, Lumbar: 40
Time Since Injury	Mean: 12 months, Range: 2-36 months

The participants in this research carried demographic characteristics that corresponded to statistical patterns of adults who suffer from spinal cord injury (SCI). Participants who participated in the study had an average age of 45, while their age range extended from 18 to 65. Out of all participants sixty were male while forty were female. A total of 30 participants suffered from mild SCI injuries, whereas 40 participants had moderate injuries and 30 participants had severe injuries. The research studied three different kinds of SCI by examining 20 cervical injuries combined with 40 thoracic cases and 40 cases of lumbar SCI.

Longer-term injury cases, besides recent injury cases, were represented in the study population through the continuous distribution spanning from two months to thirty-six months since the injuries occurred.

Table 9 Descriptive Statistics

Variable	Mean	(SD)	Minimum	Maximum
Age (years)	45 ± 12	18	65	18
Walking Ability (meters)	25 ± 10	10	10	50
Lower Extremity Strength (kg)	15 ± 5	4	5	30
Pain Levels (1-10)	6 ± 2	1	3	9

The descriptive statistics encompass an extensive summary of measurement variables from this study. The study participants had an average age of 45 ± 12 years between ages 18 to 65. Participants demonstrated walking ability that averaged 25 ± 10 meters through distance assessment while minimum scores reached 10 meters and maximum scores went up to 50 meters. The measured lower extremity strength levels reached an average of 15 kilograms with a standard deviation of 5 kilograms and distributed between 5 to 30 kilograms. The participants reported moderate pain levels rated on a scale between 1 to 10 with an average rating of 6 ± 2. Research participants needed their baseline data to evaluate the effects of preoperative physiotherapy on their recovery outcomes.

Table 10 Primary Outcome: Walking Ability

Group	Pre-Physiotherapy Walking Ability (Mean ± SD)	Post-Physiotherapy Walking Ability (Mean ± SD)	Difference (Pre - Post)	p-value
Treatment Group	25 ± 10 meters/30 seconds	50 ± 12 meters/30 seconds	25 meters	0.002
Control Group	22 ± 8 meters/30 seconds	23 ± 9 meters/30 seconds	1 meter	0.45

According to evaluation results, the test subjects who underwent pre-surgery treatment with physiotherapy improved their walking capabilities. The treatment group walked a statistically relevant 25-meter longer distance between 25 ± 10 meters baseline to 50 ± 12 meters at the end of 30 seconds ($p = 0.002$). The experimental group surpasses control participants for walking distance measurements because the control group registered an insignificant 1-meter extension from their baseline 22 ± 8 meters to 23 ± 9 meters even though statistical significance eluded their results ($p = 0.45$). Research data demonstrates that pre-surgery physiotherapy treatment produces substantial positive results for SCI patients' walking abilities.

Table 11 Secondary Outcome: Lower Extremity Strength

Group	Pre-Physiotherapy Strength (Mean ± SD)	Post-Physiotherapy Strength (Mean ± SD)	Difference (Pre - Post)	p-value
Treatment Group	15 ± 5 kg (knee)	30 ± 8 kg (knee)	15 kg	0.001
Control Group	14 ± 6 kg	15 ± 5 kg	1 kg	0.5

(knee)	(knee)

After attending pre-surgical physiotherapy, the treatment group showed improved lower extremity strength, according to the analysis results. Research demonstrated that the knee strength of the treatment group increased by 15 kg, along with a p-value of 0.001, demonstrating high significance. The control group exhibited minimal changes in the first weigh-in when strength was recorded at 15 ± 5 kg, and the second weigh-in confirmed 14 ± 6 kg with no notable statistical improvement (p = 0.5). Based on these research findings, pre-operative physiotherapy treatment proved effective in strengthening the muscles of SCI patients.

Table 12 Statistical Significance

Test	p-value	Confidence Interval
Independent t-test	0.002	[0.001, 0.003]
ANOVA (Walking Ability)	0.004	[0.002, 0.005]
ANOVA (Strength)	0.001	[0.0005, 0.0015]

The studies demonstrated statistically important differences between treatment patients and those under traditional care through their statistical results. Statistical analysis through the independent t-test demonstrated significant results with a p-value of 0.002 and a Confidence interval from 0.001 to 0.003, which validated pre-surgery physiotherapy's effectiveness. The ANOVA test for walking ability evaluation produced a statistically significant group-level difference through its p-value of 0.004 with interval [0.002, 0.005]. ANOVA results validated the significance of strength improvement for lower extremities through a p-value of 0.001 and Confidence interval [0.0005, 0.0015]. The research outcomes support the beneficial effects of the physiotherapy treatment methods.

Table 13 ANOVA (Comparing Pre- and Post-Physiotherapy Changes)

Group	Mean Difference in Walking Ability	Mean Difference in Strength	p-value (Walking Ability)	p-value (Strength)
Treatment Group	25 meters	15 kg	0.002	0.001
Control Group	1 meter	1 kg	0.45	0.5

The evaluation of average differences between groups confirmed that preliminary surgical physical therapy produces effective results. The experimental group achieved significant walking-related improvements totaling 25 meters and significant lower extremity strength gains reaching 15 kilograms. The tested statistical results demonstrated p-values below 0.002 and 0.001. The control participants displayed minimal functional changes because they walked 1 meter less and gained 1 kg of strength during the evaluation but had non-significant p-values at 0.45 and 0.5. The experimental results demonstrate that treatment patients substantially improved functionality because of physiotherapy, yet control patients experienced minimal change effects.

Table 14 Correlation (Walking Ability vs. Strength, Pain, and Quality of Life)

Variable	Walking Ability	Lower Extremity Strength	Pain Levels	Quality of Life
Walking Ability	1	0.85	-0.55	0.7
Lower Extremity Strength	0.85	1	-0.6	0.8
Pain Levels	-0.55	-0.6	1	-0.4
Quality of Life	0.7	0.8	-0.4	1

Statistical evaluation of the main study variables demonstrated significantly strong associations between these measures. Measurement results showed that increased strength levels led to better walking ability since their relationship displayed a strong positive correlation value of r = 0.85. Strength and walking ability presented positive relationships that positively linked to quality of life measures in patients (r = 0.7 and 0.8). This indicates that better wellbeing occurs when physical function shows improvement. Pain levels demonstrated a negative correlation between strength at a moderate rate, and both walking ability (r = -0.55) and strength (r = -0.6), so better function reduced reported pain amounts. Patient satisfaction demonstrates a negative relationship with pain levels, and quality of life shows an inverse correlation (r = -0.4), proving that pain reduction boosts patient perceptions of wellness. The relationships between different variables strengthen the multiple positive outcomes that physiotherapy delivers to patients.

Table 15 Independent t-test (Treatment vs. Control Group)

Group	Walking Ability (Pre)	Walking Ability (Post)	Lower Extremity Strength (Pre)	Lower Extremity Strength (Post)	p-value (Walking Ability)	p-value (Strength)
Treatment Group	25 ± 10	50 ± 12	15 ± 5	30 ± 8	0.002	0.001
Control Group	22 ± 8	23 ± 9	14 ± 6	15 ± 5	0.45	0.5

Research using an independent t-test establishes that the treatment group experienced substantial functional enhancement after preoperative physiotherapy treatment. Upon completion of pre-surgical therapy, the treatment group participants improved their walking ability to 50 ± 12 meters from 25 ± 10 meters, while their lower extremity strength increased to 30 ± 8 kg from 15 ± 5 kg. Results showed significant statistical changes for walking ability and strength under p=0.002 and p=0.001, respectively. The control group participants recorded minimal functional changes, failing to reach statistical significance since walking increased by 1 ± 1 meter while strength measurements improved by 1 ± 1 kilogram. The calculated p-values reached 0.45 and 0.5. Physiotherapy plays a positive role in enhancing functional recovery among patients who have sustained spinal cord injuries before receiving surgery.

Table 16 Post-Hoc Analysis (if ANOVA shows significant results)

Variable	Mean Difference	95% Confidence Interval	p-value
Walking Ability (Post)	Treatment vs. Control	[20.5, 29.5]	0.002
Strength (Post)	Treatment vs. Control	[12.5, 17.5]	0.001

The research project confirmed the major differences between intervention groups through additional analysis after the intervention phase. The walking ability scores of the treatment group surpassed those of the control group to a statistically significant degree because their mean difference ranged between 20.5 and 29.5 points with a p-value of 0.002. Based on data analysis, lower extremity strength showed better results for the treatment group through a [12.5, 17.5] Confidence interval range and a p-value of 0.001. The observed effects demonstrate reliability through these results and their strength level because pre-surgery physiotherapy yielded substantial functional benefits.

Table 17 Chi-Square Test Table (Categorical Variables like Gender, SCI Severity)

Variable	Category	Treatment Group	Control Group	Chi-Square Value	p-value
Gender	Male	30	25	1.2	0.5
	Female	20	25		
SCI Severity	Mild	10	10	0.8	0.75
	Moderate	20	20		
	Severe	20	20		

Categorical variables between the groups were analyzed using The Chi-square test to establish baseline equivalence. The demographic study revealed 30 male and 20 female participants in the treatment group and 25 male and 25 female participants in the control group. A Chi-square value of 1.2 and a p-value of 0.5 proved that gender distributions were identical between the study groups. Research participants distributed equally about SCI severity among the two study groups since each contained 10 mild plus 20 moderate and 20 severe cases. The Chi-square value of 0.8 and the p-value of 0.75 proved that differences between groups were not statistically significant. The data shows that both groups started with equivalent characteristics, making the outcome results reliable for analysis.

Table 18 Regression Analysis Table (Walking Ability Prediction)

Predictor Variable	Beta Coefficient	Standard Error	t-value	p-value
Lower Extremity Strength	0.75	0.1	7.5	< 0.001
Pain Levels	-0.5	0.2	-2.5	0.01
Quality of Life	0.3	0.15	2.0	0.04

The regression analysis revealed important variables that most affected walking ability post-pre-surgery physiotherapy. Lower extremity strength acted as the most influential predictor for walking ability because it demonstrated a beta coefficient of 0.75 with a standard error of

0.1 and a t-value of 7.5 at a highly significant p-value level of less than 0.001, suggesting that stronger lower extremities greatly enhanced walking performance. The regression results indicated that patients with higher pain intensity faced reduced walking ability according to a beta coefficient of -0.5, which demonstrated statistical significance ($p = 0.01$). Walking ability was positively impacted by the quality of life measured at beta = 0.3 ($p = 0.04$), yet the effect magnitude remained moderate. The study evidence confirms how physiotherapy produces twin benefits by improving physical health and psychosocial aspects, promoting functional mobility improvements in SCI patients.

Discussion

The investigation examined how pre-surgical physiotherapy treatments affect walking function and leg strength performance in patients who have sustained spinal cord injuries (SCI). The study performed a randomized controlled trial (RCT) with two groups to examine how pre-surgery physiotherapy treatment impacts results. One group participated in the intervention program, while the other group served as control without receiving any treatment. Walking ability served as the primary outcome of the research, while lower extremity strength, muscle tone range of motion, and quality of life functions were secondary measures. Research data confirmed the hypothesis that pre-surgical physiotherapy practice leads to substantial functional improvement in patients who have sustained spinal cord injuries.

Comparison with Prior Studies: Several clinical studies prove that pre-surgical physiotherapy positively affects postoperative outcomes among patients with orthopedic or neurological conditions. Patients with degenerative lumbar spine disorders achieved important gains in walking ability together with lower extremity strength advancement through pre-surgery physiotherapy interventions, according to Fors et al. (2019). Our research findings were tracked by Fors et al. (2019) by showing that SCI patients who underwent pre-surgery physiotherapy developed better walking ability and lower extremity strength. Early rehabilitation approaches showed similar findings to previous studies, which showed these techniques improve patients' physical state before surgery, enabling them to handle the demanding challenges of postoperative recovery.

Research conducted by Torres et al. (2020) and other studies has proven that early physiotherapy positively impacts gait recovery after SCI. Objectives from Torres et al. (2020) demonstrated that particular locomotor training techniques helped SCI patients achieve better results that match the research investigations. People who receive pre-surgical physiotherapy achieve superior post-operative surgical outcomes because the intervention strengthens their lower body muscles and increases their total mobility.

The research by Harvey (2016) investigates the connection between muscle strengthening and neural plasticity as a fundamental process of recovery in SCI patients. Early physiotherapy has shown their findings to produce physical strength development and neural adaptive changes for enhanced functional recovery. The assessed data points demonstrated a noticeable and favorable association between enhanced lower extremity strength outcomes and improved walking abilities, according to Harvey (2016).

Mechanisms Underpinning Observed Improvements: The observed improvements in walking ability and strength result from multiple physiological and neurophysiological mechanisms. The fundamental role in this process belongs to muscle-strengthening activities.

The targeted strength exercises, including leg presses and squats, protect SCI patients from experiencing muscle atrophy when muscles remain inactive. The enhanced strength of these muscles improved functional mobility and walking performance based on the treatment group's results during the 10MWT.

Neural plasticity is a second essential factor for this process. The study reported by Gregory and Bickel (2007) indicates how functional electrical stimulation, along with other physiotherapy techniques, activates the nervous system to rearrange neural pathways. Improved motor control and walking function resulted from these positive outcomes observed in the treatment group. Special reconstructions between brain areas and spinal cord functions emerge through repeated training that drives functional recovery after neural tissue damage.

Additionally, cardiovascular conditioning plays a role. Improving blood circulation through physiotherapy treatment is essential for SCI patients with limited mobility and subsequent blood flow difficulties. The improvement in circulatory function supports muscle recovery and accelerates healing processes, and the treatment group results illustrate this effect.

Conclusions

The research evaluated how previous surgical physical therapy affects walking ability and lower extremity strength in Spinal Cord Injury (SCI) patients. The research data confirms the assumption that implementing pre-surgical therapeutic exercises creates substantial improvements in walking capacity and lower body strength among patients with SCI. Patients who received physiotherapy before their operation significantly improved their ability to walk alongside enhanced lower extremity strength and better quality of life than patients who did not receive pre-operation physiotherapy. Statistical evidence proved the importance of pre-surgery physiotherapy as a key factor for improving functional outcomes.

Different physiological mechanisms underlying pre-surgery physiotherapy benefits include strengthening muscles, adaptability of neural pathways, and elevated heart functioning. Psychomotor improvements by pre-surgery care enhance patient recovery effectiveness before surgical procedures and establish stronger postoperative rehabilitation outcomes.

The results prove that adding pre-surgery physiotherapy to SCI patient treatment plans would substantially improve their recovery. The study findings demonstrate the necessity of adding physiotherapy as a standard preoperative treatment method specifically for SCI patients because it enhances their recovery process while lowering surgery complications.

The study provides substantial pre-surgery physiotherapy knowledge but requires investigations with bigger populations and extended observation periods to determine long-term results from these interventions. Future research, which will study different forms of physiotherapy, will need to identify the best treatments for SCI patient recovery.

The findings of this research demonstrate how pre-surgery physiotherapy becomes fundamental for SCI rehabilitation because it helps patients achieve better physical and mental health.

Implications for Clinical Practice

The research results from this study create decisive changes in how Spinal Cord Injury (SCI) patients should receive rehabilitation treatment in clinical settings. This research proves that pre-surgery physiotherapy should become integral to standardized SCI patient care strategies since it produces favorable immediate and prolonged functional outcomes. This

research study provides several important implications which guide clinical practice.

Incorporating Pre-Surgery Physiotherapy into Standard Care Protocols: According to clinical practice findings, pre-surgery physiotherapy therapy should become integral to SCI patient care since it improves walking ability and lower extremity strength. The early implementation of physiotherapy within treatment practices enables clinicians to develop optimum physical states before surgery, producing superior surgical achievements and reduced recovery time. Recovery progresses faster when patients receive rehabilitation exercises designed to enhance their strength and learn gait patterns and flexibility through program-specific programs.

Early Intervention to Prevent Secondary Complications: Due to the sedentary state, patients who suffer spinal cord injuries frequently experience muscle atrophy, joint contractures, and respiratory problems. The research findings indicate that starting physiotherapy treatment early will help decrease the likelihood of secondary complications arising after the surgery. Physicians must include exercises aiming at muscle strength, joint flexibility, and circulatory system wellness to decrease the dangers resulting from immobility. Physiotherapy implemented during the early stages decreases the probability of pressure ulcers and musculoskeletal deformities, which frequently affect SCI patients.

Improved Psychological and Emotional wellbeing: During rehabilitation programs, the mental health status of patients with spinal cord injuries remains poorly supported, although mental and emotional state directly impacts recovery. The combination of pre-operative physical therapy secures improved physical ability with concurrent psychological advantages by giving patients greater rehabilitation control. Healthcare providers ought to implement mental health treatments and motivational counseling in addition to physical therapy since the treatment group data reveals the necessity of whole-person medical care to boost life quality and mental state.

Each Patient Needs Different Physiotherapy Plans Which Produce The Most Effective Outcomes: Future clinical practices must focus on individualized treatment approaches because the research implemented a standardized 6-week physiotherapy protocol. Every neurological patient who experiences spinal cord injury requires different degrees of care and follows a distinct path of recovery. Physiotherapy programs for preoperative care must be customized based on a patient's specific injury level, functional capacity, and individual goal requirements. Patients who have incomplete spinal cord injuries should engage in a complex strength-training program, but those with complete injuries will gain the most benefits from exercises that focus on both passive movement and respiratory care.

Long-Term Rehabilitation and Monitoring: Analysis of pre-surgery physiotherapy benefits is restricted because the study tracks patients only for a short-term period. Medical staff must apply long-term observation with ongoing rehabilitative therapy to sustain enhanced muscle strength and better mobility results in treatment. Patients should maintain their post-surgical physiotherapy sessions because preoperative therapy creates strong outcomes that require further use to achieve the best possible results. After clinical treatment, telerehabilitation and home exercise programs can expand physiotherapy benefits into outpatient settings.

Recommendations

Based on the findings and discussion, the following recommendations were made;

1. The standard surgical preparation for SCI patients should include organized pre-operative physiotherapy programs for maximum improvement in walking abilities.
2. Lower limb strengthening exercises administered early before surgery produce better mobility results through their positive impact on muscle strength.
3. Intense physiotherapy therapy for a week or less helps effectively prevent muscle atrophy and joint stiffness in SCI patients before surgery.
4. Organizations should use functional mobility assessments which consist of a 10-meter Walk Test combined with isokinetic strength tests to determine successful outcomes from SCI rehabilitation treatments.
5. PROMs should be included in SCI care to monitor patient life quality since the introduction of physiotherapy therapy resulted in noticeable improvements.
6. Multiple healthcare professionals require training for preoperative rehabilitation that simultaneously builds surgical patients' functional performance and mental readiness to achieve better surgical results.

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