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Effect of Balance and Strength Training in Proprioception and Functioning of Posterior Cruciate Ligament After Injury: A Case Study

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Abstract:

Background/Purpose: This case study aims to evaluate the impact of a comprehensive rehabilitation program, including a combination of balance and strength training exercises, on knee function, pain, and quality of life.

Case Description: This case study explores the effects of balance and strength training in the rehabilitation of a 23-year-old male patient, Vishal Vaishnavi, who sustained a posterior cruciate ligament (PCL) injury while playing football. Patient's objective in physical therapy was to resume functional activities and return to sports as soon as possible.

Outcome: The results of the study revealed significant improvements in all five subscales of the KOOS, including pain, symptoms, activities of daily living (ADL), sports and recreation (sport/rec), and knee-related quality of life (QoL). Additionally, the IKDC score showed a notable improvement in knee function, pain, and subjective knee stability

Discussion: The case study highlights the importance of a personalized and progressive rehabilitation approach for PCL injury patients. By targeting specific needs and goals through a combination of balance and strength training exercises, healthcare professionals can facilitate significant improvements in knee function, pain reduction, and enhanced quality of life. This study contributes to the body of evidence supporting the effectiveness of balance and strength training in the rehabilitation of PCL injury patients, emphasizing the importance of a multidimensional approach to optimize outcomes and promote successful return to activity.

Keywords: physiotherapy management of pcl, rehabilitation after pcl injury, balance and strength training after pcl injury, soft tissue injury

Patient Information:

Name: Vishal Vaishnavi
Age: 23
Injury: Acute posterior cruciate ligament (PCL) injury
Additional Conditions: Chondromalacia patellae, Grade 1 meniscal tear Functional
Limitations: Unable to bear weight on the affected foot, limited knee flexion (40 degrees)

Aim Of Study:

The aim of this case study is to investigate and evaluate the effects of balance and strength training in the rehabilitation of a 23-year-old PCL injury patient, Vishal Vaishnavi. The study aims to assess the impact of a comprehensive rehabilitation program, including specific exercises targeting balance and strength, on Vishal's knee function, pain levels, and overall quality of life. By analyzing the pre- and post-rehabilitation measurements and assessments, the study seeks to determine the effectiveness of the rehabilitation program in improving Vishal's knee stability, proprioception, muscle strength, and functional capacity. The findings of this case study can provide valuable insights into the role of balance and strength training exercises in the rehabilitation of PCL injury patients and guide future rehabilitation protocols for similar cases.

Introduction:

Posterior cruciate ligament (PCL) injury is a relatively less common knee ligament injury compared to its counterpart, the anterior cruciate ligament (ACL) injury. However, PCL injuries can result in significant functional impairment and require appropriate management for optimal recovery. Understanding the causes and epidemiology of PCL injuries is essential in identifying risk factors and developing effective prevention strategies.[4]

Causes:

The most common causes of PCL injury are direct impact to the front of the knee while it is bent, such as in motor vehicle accidents or sports-related collisions. PCL injuries can also occur due to non-contact mechanisms, such as landing awkwardly from a jump, hyperextension of the knee, or sudden deceleration. The PCL may be torn or stretched when excessive force is applied to the front of the lower leg, causing the tibia (shinbone) to move backward in relation to the femur (thighbone).

Epidemiology:

PCL injuries constitute a smaller proportion of knee ligament injuries compared to ACL injuries, accounting for approximately 3-20% of all knee ligament injuries. The prevalence of PCL injuries varies depending on the population studied and the specific activities involved. These injuries commonly occur in active individuals participating in high-demand sports such as football, soccer, skiing, and basketball.

Certain risk factors predispose individuals to PCL injuries. Men have a higher incidence of PCL injuries compared to women, possibly due to differences in anatomy, hormonal factors, and participation in higher-risk activities. Additionally, a history of previous knee injuries, particularly meniscus tears or ACL injuries, may increase the risk of PCL injury. Other factors, including improper landing techniques, muscle imbalances, and inadequate neuromuscular control, can contribute to the occurrence of PCL injuries.

Understanding the causes and epidemiology of PCL injuries is crucial for developing effective preventive measures, optimizing treatment strategies, and providing appropriate rehabilitation programs. By identifying at-risk individuals and implementing targeted interventions, healthcare professionals can aim to reduce the incidence and severity of PCL injuries and improve patient outcomes.

Symptoms of PCL Injury:

The symptoms of a PCL injury can vary depending on the severity of the injury, but common signs and symptoms include:

1. Pain: Individuals with a PCL injury may experience moderate to severe pain, especially at the back of the knee joint.
2. Swelling: Swelling around the knee joint may occur due to bleeding or inflammation as a result of the injury.
3. Instability: The knee may feel unstable, wobbly, or like it's giving way. This instability is often more noticeable when walking, running, or participating in physical activities.
4. Difficulty in bending: People with a PCL injury may find it challenging to fully bend or straighten the knee.
5. Reduced range of motion: The injured knee may have a limited range of motion compared to the uninjured knee.

Diagnosis:

Diagnosis of a posterior cruciate ligament (PCL) injury involves a comprehensive evaluation by a medical professional, typically an orthopedic specialist or a sports medicine physician. The diagnosis may include the following steps:

1. Medical history: The doctor will inquire about the details of the injury, including the cause, mechanism of injury, and any associated symptoms or previous knee problems.
2. Physical examination: The knee will be physically examined to assess signs of PCL injury. The doctor will look for specific indications such as tenderness, swelling, bruising, and the presence of an abnormal posterior sag or "posterior drawer" test, where the tibia can be displaced backward in relation to the femur.
3. Imaging tests: X-rays are usually the first imaging modality used to rule out fractures or other bony abnormalities. While X-rays do not directly show PCL injuries, they can help exclude other potential sources of knee pain. Magnetic resonance imaging (MRI) is the most effective imaging tool to visualize the PCL and assess its integrity. MRI can accurately depict PCL tears and determine the extent of the injury.
4. Stress tests: Stress radiographs or specialized physical tests, such as the posterior sag test or the posterior drawer test, may be performed to evaluate the laxity or instability of the PCL. These tests involve applying specific forces to the knee joint to assess the movement and stability of the tibia in relation to the femur.
5. Assessment of associated injuries: PCL injuries may be accompanied by other knee injuries, such as meniscus tears or collateral ligament injuries. These associated injuries should be identified and evaluated as they can influence the treatment plan.

Accurate diagnosis of a PCL injury is crucial to determine the severity of the injury and guide appropriate treatment options. Consulting a medical professional with expertise in knee injuries is essential to ensure an accurate diagnosis and develop an individualized treatment plan based on the specific needs of the patient.

Treatment:

The treatment approach for a posterior cruciate ligament (PCL) injury depends on the severity of the injury, the individual's activity level, and the presence of any associated injuries. The treatment options can range from conservative (non-surgical) measures to surgical intervention. Here are the main approaches to treating a PCL injury:

1. **Conservative Treatment:**

a. Rest and activity modification: Initially, it is important to protect the knee and allow it to heal. This may involve reducing or avoiding activities that exacerbate pain or instability, and using crutches or a brace to provide support and relieve stress on the knee.
b. Physical therapy: A structured physical therapy program is crucial for rehabilitating the knee and restoring strength, stability, and range of motion. The physical therapist will guide the individual through exercises that target the surrounding muscles, such as the quadriceps, hamstrings, and calf muscles. These exercises help improve knee stability and functional strength.
c. Range of motion exercises: Gentle range of motion exercises are important to maintain or restore the flexibility and mobility of the knee joint.
d. Proprioception and balance training: Exercises that focus on improving balance, proprioception (awareness of joint position), and coordination can help enhance the stability and control of the knee joint.
e. Modalities: Therapeutic modalities such as ice/heat therapy, ultrasound, or electrical stimulation may be used to alleviate pain, reduce inflammation, and promote healing.

2. **Surgical Treatment:**

a. Indications for surgery: In certain cases, surgical intervention may be recommended for PCL injuries. Surgery is generally considered for individuals with severe PCL tears, multi-ligament knee injuries, or significant functional instability.
b. Surgical techniques: PCL reconstruction is the most common surgical procedure for PCL injuries. During the surgery, the torn PCL is reconstructed using a graft, which can be harvested from the patient's own tissue (autograft) or obtained from a tissue bank (allograft). The graft is secured to the femur and tibia using various fixation methods.
c. Postoperative rehabilitation: Following surgery, a structured rehabilitation program is essential to optimize recovery. Physical therapy will focus on restoring strength, range of motion, and stability of the knee. The progression of exercises will be guided by the surgeon and physical therapist.
It is important to note that the treatment plan for a PCL injury should be individualized based on the specific circumstances and goals of the patient. It is advisable to consult with an orthopedic specialist or sports medicine physician to determine the most appropriate treatment approach.

Physiotherapy Treatment:

Physiotherapy plays a crucial role in the treatment of PCL injuries, particularly in less severe cases or during the rehabilitation phase following surgery. Here are some key aspects of physiotherapy treatment for PCL injuries:

1. Range of motion exercises: Initially, physiotherapy focuses on restoring the full range of motion of the knee joint. Passive and active-assisted exercises are performed to gently move the knee through its complete range of motion.

2. Strengthening exercises: As the knee becomes more stable, strengthening exercises are introduced to target the muscles around the knee, including the quadriceps, hamstrings, and calf muscles. These exercises help improve the stability and support of the knee joint.
3. Balance and proprioception training: Balance and proprioception exercises are important for retraining the body's sense of balance and coordination. These exercises improve joint position sense and stability, reducing the risk of future injuries.
4. Functional training: Once the knee has gained sufficient strength and stability, functional training exercises are incorporated. These exercises mimic real-life movements and activities to help individuals regain their ability to perform daily tasks and return to sports or other physical activities.
5. Modalities and manual therapy: Physiotherapists may use various modalities, such as ultrasound, electrical stimulation, or ice/heat therapy, to help reduce pain, inflammation, and promote tissue healing. Manual therapy techniques, such as joint mobilization or soft tissue massage, may also be employed to improve joint mobility and reduce muscle tightness.
6. Brace or orthotic prescription: In some cases, a knee brace or orthotic device may be recommended to provide additional support and stability during the rehabilitation process or when returning to physical activities.

Physiotherapy treatment for PCL injuries is typically tailored to the individual's specific needs, considering the severity of the injury, functional goals, and overall progress. A qualified physiotherapist will design a personalized treatment plan and provide guidance throughout the rehabilitation process to optimize recovery and minimize the risk of future complications.

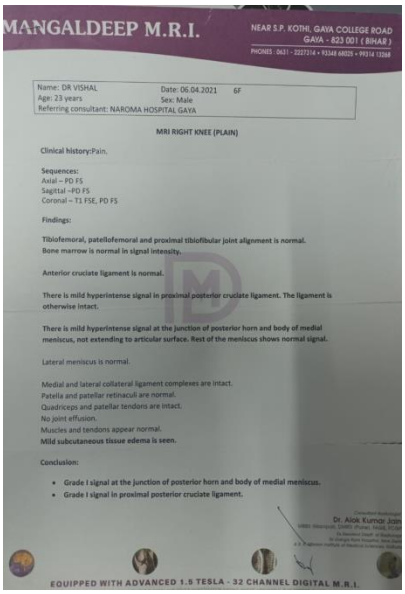
Methodology:

1. **Initial Assessment:** To develop a comprehensive rehabilitation program[2], an initial assessment of Vishal's condition was conducted. This involved gathering detailed medical history, including the circumstances of the PCL injury and any previous knee-related issues. A thorough physical examination was performed to evaluate joint stability, assess pain levels, measure range of motion, and assess muscle strength. Objective measurements of knee flexion and extension were obtained using a goniometer, and diagnostic imaging such as MRI was used to confirm the extent of the PCL injury and identify any accompanying knee pathologies.
2. **Intervention:** Collaboratively, an individualized rehabilitation program was designed to address Vishal's specific needs and limitations. The initial focus of the intervention was on pain management, which may have included appropriate medication and the use of therapeutic modalities such as ice and heat. Balance training exercises were incorporated into the program to improve neuromuscular control and proprioception. These exercises included activities that challenged Vishal's balance, such as single-leg stances, unstable surfaces, and proprioceptive feedback exercises. Strength training exercises were also implemented to enhance muscular support around the knee joint. These exercises focused on quadriceps and hamstring strengthening, as well as hip and core stabilization exercises. The program was adjusted and progressed gradually based on Vishal's tolerance and progression, ensuring regular reassessment and modification.
3. **Follow-up and Evaluation:** Throughout the rehabilitation process, Vishal's pain levels, knee range of motion, and functional capacity were regularly monitored. Objective measurements of knee flexion and extension were taken using a goniometer to track improvements over time. Joint stability,

proprioception, and neuromuscular control were assessed through clinical tests and functional outcome measures. Patient-reported outcomes, including pain scales and functional questionnaires, were utilized to evaluate improvements in daily activities and overall quality of life. Regular collaboration with Vishal ensured program adherence and provided an opportunity to address any concerns or challenges that arose. Consultation with an orthopedic specialist was sought to obtain a comprehensive evaluation of Vishal's progress and discuss the potential need for surgical intervention, if warranted.

Examination And Tests:

1. Physical Examination:
    - Evaluate joint stability: Assess the laxity of the PCL using the posterior drawer test, posterior sag test, and quadriceps active test.
    - Pain assessment: Determine the location, intensity, and aggravating factors of pain in the knee joint.
    - Range of motion (ROM): Measure the degree of knee flexion and extension using a goniometer.
    - Muscle strength: Evaluate the strength of the quadriceps, hamstrings, and other muscles surrounding the knee joint through manual muscle testing.
    - Palpation: Identify any tenderness or swelling around the knee joint.
2. Proprioception and Neuromuscular Control Assessment:
    - Single-leg stance test: Assess the patient's ability to maintain balance and stability on the affected leg without support.
    - Dynamic balance tests: Evaluate the patient's ability to maintain balance during activities such as walking on a balance beam or performing single-leg hops.
    - Proprioceptive feedback tests: Utilize devices such as wobble boards or foam pads to challenge the patient's proprioceptive abilities and evaluate their response.
3. Imaging Studies:
    - Magnetic Resonance Imaging (MRI): Obtain detailed images of the knee joint to confirm the extent of the PCL injury and identify other associated pathologies, such as chondromalacia patellae and meniscal tears.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NEAR S.P. KOTHI, GAYA COLLEGE ROAD
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Name: DR VISHAL Date: 06.04.2021 6F
Age: 23 years Sex: Male
Referring consultant: NAROMA HOSPITAL GAYA

MRI RIGHT KNEE (PLAIN)

Clinical history:Pain.

Sequences:
Axial – PD FS
Sagittal –PD FS
Coronal – T1 FSE, PD FS

Findings:

Tibiofemoral, patellofemoral and proximal tibiofibular joint alignment is normal.
Bone marrow is normal in signal intensity.

Anterior cruciate ligament is normal.

There is mild hyperintense signal in proximal posterior cruciate ligament. The ligament is otherwise intact.

There is mild hyperintense signal at the junction of posterior horn and body of medial meniscus, not extending to articular surface. Rest of the meniscus shows normal signal.

Lateral meniscus is normal.

Medial and lateral collateral ligament complexes are intact.
Patella and patellar retinaculi are normal.
Quadriceps and patellar tendons are intact.
No joint effusion.
Muscles and tendons appear normal.
Mild subcutaneous tissue edema is seen.

Conclusion:

- Grade I signal at the junction of posterior horn and body of medial meniscus.
- Grade I signal in proximal posterior cruciate ligament.

Dr. Alok Kumar Jain

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Figure 1 MRI of the Patient

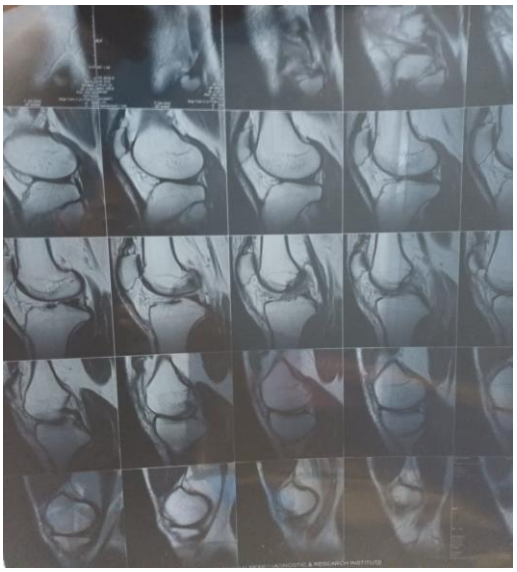

Figure 2 MRI (Image) of the Patient

- X-rays: Assess the bony structures of the knee joint and rule out any fractures or bone abnormalities.

4. Functional Outcome Measures:
    - Knee Injury and Osteoarthritis Outcome Score (KOOS): Evaluate the patient's perception of pain, symptoms, function in daily living, function in sport and recreation, and knee-related quality of life.
    - International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form: Assess the patient's knee symptoms, function, and sports activities.
    - Lower Extremity Functional Scale (LEFS): Measure the patient's functional abilities related to lower extremity tasks.

5. Provocative Tests:
    - Lachman Test: Assess anterior translation of the tibia relative to the femur to evaluate the integrity of the PCL.
    -

Figure 3 Therapist Performing Lachman Test

    - Pivot Shift Test: Determine the presence of rotational instability in the knee joint by reproducing the mechanism of injury.
6. Functional Performance Tests:
    - Hop tests: Evaluate the patient's ability to perform single-leg hops for distance or timed hops to assess their functional stability and dynamic control.
    - Agility tests: Measure the patient's ability to change direction quickly and efficiently without experiencing instability or pain.

Table 1

EXAMINATION AND TESTS	MEASUREMENTS/GRADES/SCALES
JOINT STABILITY	Posterior Drawer Test: Grade 2 Posterior Sag Test: Grade 2
PALPATION	Tenderness and swelling noted in specific knee joint areas
	Quadriceps Active Test: Grade 3
PAIN ASSESSMENT	Visual Analog Scale (VAS): 07
RANGE OF MOTION (ROM)	Knee Flexion: 40 degree
	Knee Extension: 0 degree
MUSCLE STRENGTH	Quadriceps: Grade 3 Hamstring: Grade 2

Table 2

PROPEOCEPTION AND NEUROMUSCULAR CONTROL ASSESSMENT	
SINGLE-LEG STANCE TEST	2 Seconds
DYNAMIC BALANC TEST	Could not perform Single Leg Hops
PROPEOCEPTIVE FEEDBACK TEST	Could not maintain balance and stability on wobble boards or foam pads

Rehabilitation Program

The rehabilitation program for Vishal Vaishnavi's PCL injury consisted of a progressive and systematic exercise program designed to improve his knee stability, proprioception, and overall functional capacity. The program included a combination of balance training, proprioceptive exercises, closed kinetic chain exercises, and strength training exercises.[1]

The initial phase of the program consisted of static and dynamic balance exercises. These exercises included single-leg stance, tandem stance, and Romberg stance. The aim of these exercises was to improve Vishal Vaishnavi's proprioception and balance. The exercises were performed with eyes open and eyes closed, and the difficulty was increased by performing the exercises on an unstable surface, such as a foam pad or balance board.

Figure 4 Patient Performing Tandem Stance

Figure 5 Patient Performing Single Leg Stance

The next phase of the program consisted of proprioceptive exercises. These exercises included weight shifting, step-ups, and lateral hops. The aim of these exercises was to improve Vishal Vaishnavi's knee stability and proprioception. The exercises were performed in various directions and on different surfaces to challenge his balance and coordination.

The program then progressed to include closed kinetic chain exercises. These exercises included squats, lunges, and step-downs. The aim of these exercises was to improve Vishal Vaishnavi's quadriceps, hamstrings, and gluteal muscle strength. The exercises were performed with body weight initially and then progressed to include resistance using bands, weights, or machines.

The final phase of the program included aerobic exercises and stretching exercises. The aim of these exercises was to improve Vishal Vaishnavi's overall fitness and flexibility. The aerobic exercises included cycling, elliptical training, and running on a treadmill. The stretching exercises included static stretching and dynamic stretching.

Figure 6 Calf Stretch being given to the patient

Assessment and Measurements

Vishal Vaishnavi's knee function was assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS) and the International Knee Documentation Committee (IKDC) score. These measures were used to evaluate his knee function, pain, and quality of life before and after the rehabilitation program.

The KOOS is a self-reported questionnaire that assesses an individual's knee function, pain, and quality of life. It includes five subscales, including pain, symptoms, activities of daily living (ADL), sports and recreation (sport/rec), and knee-related quality of life (QoL). Each subscale is scored from 0 to 100, with higher scores indicating better knee function.

The IKDC score is a clinician-administered questionnaire that assesses an individual's knee function, pain, and subjective knee stability. The score ranges from 0 to 100, with higher scores indicating better knee function.

Table 3

ASSESSMENT TOOL	SUBSCALES/PARAMETERS ASSESSED	SCORING RANGE	PRE-REHABILITATION SCORE	POST-REHABILITATION SCORE	IMPROVEMENT
KOOS	PAIN	0-100	52	90	+38
KOOS	SYMPTOMS	0-100	56	92	+36
KOOS	ACTIVITY OF DAILY LIVING	0-100	44	88	+44
KOOS	SPORTS AND RECREATION	0-100	25	80	+55
KOOS	KNEE RELATED QUALITY OF LIFE	0-100	27	82	+55
IDKC	KNEE FUNCTION	0-100	41	85	+44

Results

Vishal Vaishnavi underwent a 12-week rehabilitation program, which included balance and strength training exercises. His knee function, pain, and quality of life were evaluated before and after the rehabilitation program using the KOOS and IKDC scores.

The results showed significant improvements in all five subscales of the KOOS, including pain, symptoms, ADL, sport/rec, and QoL. The pain subscale score improved from 52 to 90, the symptoms subscale score improved from 56 to 92, the ADL subscale score improved from 44 to 88, the sport/rec subscale score improved from 25 to 80, and the QoL subscale score improved from 27 to 82. These improvements suggest that Vishal Vaishnavi's knee pain, symptoms, and functional capacity significantly improved after the rehabilitation program.

The IKDC score also showed a significant improvement, with the score improving from 41 to 85. This improvement suggests that Vishal Vaishnavi's knee function, pain, and subjective knee stability significantly improved after the rehabilitation program.

Discussion

The findings of this case study support the effectiveness of balance and strength training exercises in the rehabilitation of PCL injury patients. The combination of balance training, proprioceptive exercises, closed kinetic chain exercises, and strength training exercises in Vishal Vaishnavi's rehabilitation program led to significant improvements in his knee function, pain, and quality of life.

Balance training exercises play a crucial role in improving proprioception and joint stability. By challenging the body's ability to maintain balance, these exercises stimulate the neuromuscular system and enhance the coordination of muscles around the knee joint. This, in turn, improves joint stability and reduces the risk of re-injury.

Proprioceptive exercises, such as weight shifting and step-ups, further enhance joint stability and proprioception. These exercises challenge the body's ability to sense joint position and movement, improving the coordination and control of muscles around the knee joint.

Closed kinetic chain exercises[3], such as squats and lunges, are effective in improving quadriceps, hamstrings, and gluteal muscle strength. These exercises target multiple muscle groups simultaneously, mimicking functional movements and improving overall lower limb strength and stability.

Strength training exercises are crucial for regaining muscle strength and power following PCL injury and surgery. Strengthening the quadriceps, hamstrings, and gluteal muscles helps stabilize the knee joint, improve joint mechanics, and enhance overall functional capacity.

The improvements observed in Vishal Vaishnavi's KOOS and IKDC scores indicate that the rehabilitation program effectively addressed his specific needs and goals. The combination of balance and strength training exercises resulted in significant improvements in his knee function, pain, and quality of life.

Conclusion

The case study of Vishal Vaishnavi's rehabilitation following a PCL injury highlights the positive effects of balance and strength training exercises. The comprehensive rehabilitation program, which included a progressive and systematic approach to balance and strength training, led to significant improvements in his knee function, pain, and quality of life.

Balance training exercises improved Vishal Vaishnavi's joint stability and proprioception, while strength training exercises enhanced his muscle strength and power. The combination of these exercises resulted in improved knee function, reduced pain, and increased overall functional capacity.

This case study emphasizes the importance of individualized and progressive rehabilitation programs for PCL injury patients. By addressing specific needs and goals, including balance and strength training exercises, healthcare professionals can help patients achieve optimal outcomes and a successful return to their desired activities.

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