

# Getting athletes back in the game: A comprehensive rehabilitation assessment of knee injuries

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## Abstract

Movement is an essential characteristic that has developed over the course of human evolution. With the inclusion of various populations in sports activities, sports have become an important part of people's daily lives. Knee injuries are common among athletes, with knee joint being the most vulnerable to various injuries. Knee injuries require appropriate treatment to allow the athlete to return to their sports activities. Additionally, this study aimed to increase awareness of the importance of preventing knee injuries in sports and to highlight the potential impact of such injuries on an athlete's ability to participate in their sport.

A cross-sectional study was conducted to evaluate the functional outcomes of athletes with knee injuries. The study included 38 patients with knee injuries (ACL, meniscal injuries, collateral ligament injuries) out of which 21 were physically active athletes, 9 were not, but they were athletes who were not involved in sports at the time of the testing and 8 were recreational athletes. The majority of respondents (76%) reported that they sustained the injury during sports activities. Knee pain was reported as at least once a week by most respondents.

The study highlights the importance of proper knee injury prevention measures during sports activities and the need for prompt and effective rehabilitation for those who do suffer injuries. Overall, these findings have important implications for the treatment and management of knee injuries among athletes and individuals seeking to maintain an active lifestyle.

## Keywords

- knee rehabilitation
- physical activity
- athletes
- physical therapy
- knee pain

## Contribution

- A – the preparation of the research project
- B – the assembly of data for the research undertaken
- C – the conducting of statistical analysis
- D – interpretation of results
- E – manuscript preparation
- F – literature review
- G – revising the manuscript

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## Introduction

Sports represent an important part of people's daily lives. Increasingly, various sports activities, whether professional or recreational, are associated with people's everyday lives. The great actualization of sport today and the inclusion of various populations in it, regardless of their age or gender, indicates the beneficial effect of sport on people's health. This is especially true for recreational sports activities in which millions of people from around the world participate.<sup>1,2</sup>

Sports injuries can be diverse, but most commonly they involve injuries to the joints and muscles, as these are the most exposed parts of the musculoskeletal system. Knee injuries, due to their complex anatomical structure, can range from simple to highly complex. All of these injuries require appropriate treatment to allow the athlete to return to their sports activities.<sup>3,4</sup>

The knee joint (*articulatio genu*) is one of the most complex joints in the human body. Due to its functions, the knee is anatomically positioned where ligaments provide its stability positioned laterally, medially, and inside the joint. The rehabilitation program for ligament injuries is most commonly performed after surgical intervention. The surgical intervention addresses the primary problem, followed by a phase of recovery, where physical therapy plays the most important role.<sup>5</sup>

The knee joint must also provide stability in other directions, such as backward and sideways. In an upright position, it carries about 70% of the body weight, while in a crouched position, it can carry up to 90% of the body weight. The main rule for the knee joint is early diagnosis and treatment of knee injuries, which leads to shorter absences from work and fewer long-term consequences.<sup>6</sup>

The functional examination of the knee can be conducted in a seated, supine or prone position. During the examination, attention should be paid to: the excursion of the patella and whether the movement is free and easy; the range of motion of the tibiofemoral joint; whether the patient feels pain during movement and the localization of the pain; and what limits the range of motion.<sup>7</sup>

There are many scales for complex functional assessment of the knee joint. Many of the scales are given for a specific category of athletes or for patients with a specific diagnosis or operation. Each scale has certain advantages and disadvantages. For everyday activities, full extension when walking or standing has greater functional significance, while full flexion of about 135° does not have as much functional significance.<sup>8</sup>

The most commonly tested complex functional activities of the lower extremity are:

- squatting (symmetric dorsal flexion in the ankle joints);

- toe raises (symmetric plantar flexion on both feet);
- step-ups with squatting;
- one-legged standing;
- climbing and descending stairs;
- walking on tiptoes;
- step-ups and running.<sup>9</sup>

The anterior cruciate ligament is one of the most commonly injured ligaments of the knee, occurring mainly in the young or sports-active population. Many patients are left with significant disability after an anterior cruciate ligament injury. The injury leads to a change in knee mechanics. This mechanical deficit can also lead to an increased risk of meniscal injury. Understanding this pathology and preventing associated meniscal pathology is the key to managing this condition. Treatment aims to protect the meniscus by modifying the level of activity or by reconstructing the anterior cruciate ligament.<sup>10</sup>

The goal of treating patients with anterior cruciate ligament injury is to prevent joint instability and the associated occurrence of meniscal injury. After the acute injury, the main indications for surgical reconstruction are related to the degree of knee instability and the level of activity. Knee activity levels depend largely on sports activities or activities related to work. Patient examination with a history of illness is very important in making decisions about surgical reconstruction or conservative treatment. However, in the less active group, the decision for surgery becomes controversial. A plan for conservative management of the injury with long-term physical therapy and activity avoidance can be adopted. If patients have greater instability in the knee despite all goals, surgical reconstruction is indicated.

In chronic cases, the main indication for surgical reconstruction is recurrent knee instability. Other types of surgical intervention may also be required to prevent associated pathologies, such as arthroscopy, partial meniscectomy, or meniscus repair. High tibial osteotomy may also be indicated to correct varus of the knee, particularly in degenerative cases with complex instability.

The early rehabilitation of postoperative anterior cruciate ligament reconstruction focuses on protecting the new ligament without any hindrances. This approach may lead to numerous postoperative complications such as stiffness, weakness, and patellofemoral problems. Rehabilitation after reconstructive surgery of the anterior cruciate ligament is necessary for functionality.

Currently, there is no functional algorithm for appropriate treatment for individuals with surgical reconstruction of the ligament. The relationship between the

biomechanical dose of exercises after surgery and the graft and knee healing response is not well understood. Appropriate healing of neuromuscular control of the knee after injury can lead to an increased improvement in results in terms of restoring functionality and preventing recurring injuries. There are two main goals in the rehabilitation of the anterior cruciate ligament:

- strengthening the entire knee joint;
- greater knee functionality in carrying out appropriate activities.<sup>11</sup>

These desired goals can only be achieved through intensive rehabilitation to improve strength, proprioception, and reaction time to activities of daily living in order to increase involvement in these activities. The primary damage that occurs after surgical reconstruction is instability, which can lead to additional joint damage. Many studies indicate that preoperative rehabilitation is quite effective in increasing strength and stability.<sup>12</sup>

## Methodology

The main motivation for this research was primarily the percentage of accompanying diseases that can occur alongside this type of pathology and their timely suppression in order to reduce the unforeseen costs that follow the occurrence of these associated tissue damages. Therefore, the main motivation for the development of this study is to incorporate the entire injury, along with the accompanying diseases and rehabilitation, into one scientific effort.

The aim of the study was to examine the functional ability of patients after knee joint damage, both postoperatively and conservatively. Functional ability is a key factor for activities of daily living, therefore an additional aim of the study was to examine the activity level of patients in performing activities of daily living.

The study is an average epidemiological study that includes 38 patients from the municipality of Struga who have been diagnosed with knee injuries. The majority of patients are athletes, while some engage in sports recreationally. Additionally, a very small proportion of patients have sustained an injury without any typical mechanism of injury associated with sports.

Any comorbidities related to the cardiovascular system or any systemic bone and joint disorders will not be included in the study, and the patients will not be examined for these conditions.

To achieve the objectives of this specialized study, the patients were evaluated according to:

- gender, age, and sports activity of the patients;

- pain scale (numerical);
- questionnaire for quality of life after anterior cruciate ligament injury (the questionnaire was adopted from the National Institute of Public Health of the Republic of Turkey).<sup>13</sup>

## Results

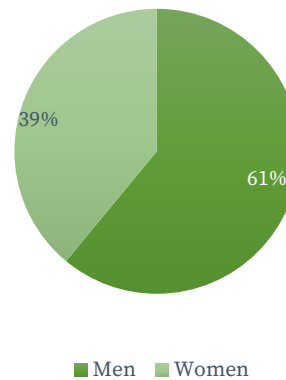


Figure 1. Distribution by gender

According to Figure 1, out of the 38 participants, 15 are females (39%) and 23 are males (61%). In this part of the study, not all patients are athletes. Some of them have suffered the injury outside the scope of sports medicine.

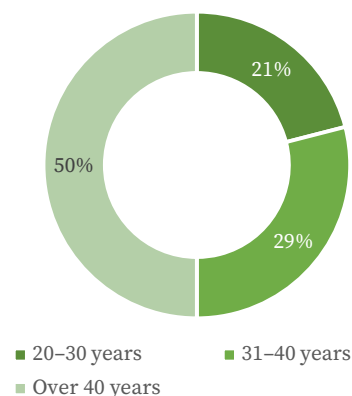


Figure 2. Age of the participants

According to the conducted questionnaires of the patients, they were divided into 3 age groups. The first group includes patients aged 20-30 years and there are 8 patients (21%) in this group, the second group includes patients from 30 to 40 years old, with 11 patients (29%),

and the third group includes patients over 40 years old, with 19 patients, or 50% of the participants. The youngest one is 21 years old, the oldest was 53 years old.

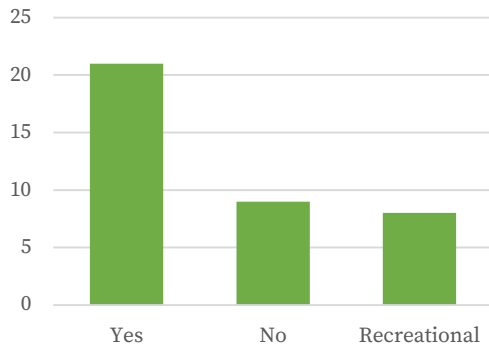


Figure 3. Questionnaire for sports activity

According to Figure 3, the participants were asked about their sports activity. According to the above data, 21 individuals are sports-active individuals or professional players (55%), 9 individuals do not engage in sports and sports activities, and the mechanism of knee injury is of a different nature (24%), and 8 patients have stated that they engage in recreational sports in their free time (21%).

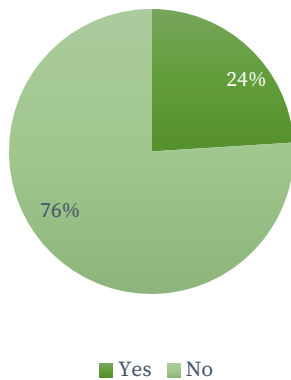


Figure 4. Injuries during sports activities

According to Figure number 4, the patients were asked about the mechanism of their knee injury. Of these, 29 patients confirmed that they had suffered an injury during some sports activity (76%), while a small portion of the participants, that is 9 patients (24%), reported that the mechanism of the injury was not related to sports activity.

The following questions relate to all patients and are related to their pain after the injury. The results are as it is shown in Figure 5.

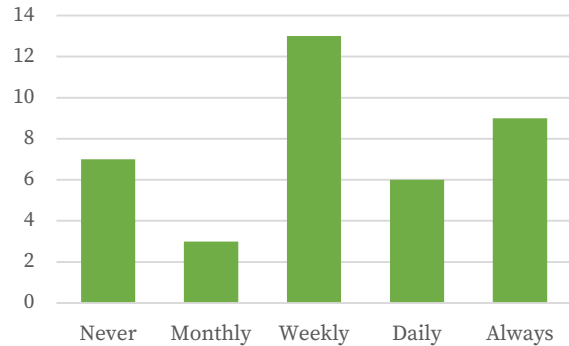


Figure 5. Frequency of knee pain

According to Figure 5, patients were asked about the frequency of their knee pain. The majority of them reported having knee pain once a week, specifically 13 patients (34%). Most of them were athletes who were in the early stages of rehabilitation before starting intensive exercises. The least number of patients, specifically 3, reported experiencing pain rarely, even once a month (8%). The purpose of the question was to explain the knee pain even during rest, especially in the early stages of rehabilitation.

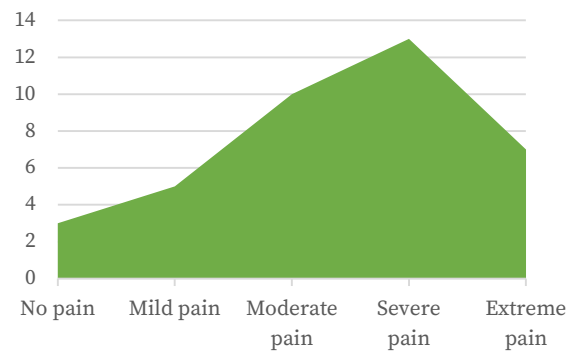


Figure 6. Degree of pain among athletes when trying to straighten their knee

According to Figure 6, patients were examined in regards to how much pain they feel when attempting to straighten the injured limb, i.e. the knee. Of them, 3 patients stated that they have no pain during such activity (8%), 5 patients reported mild pain (13%), 10 patients reported moderate pain (26%), 13 patients reported

severe pain during such activity (26%), and 7 patients reported extremely severe pain (18%). Since most of the patients were surveyed 3 weeks after the injury, the frequency of this type of pain when straightening the knee is justified.

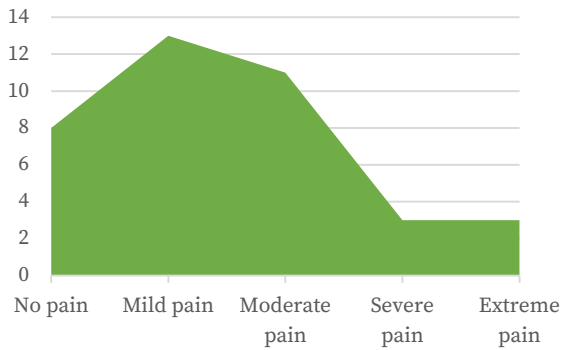


Figure 7. Pain in athletes when trying to flex the knee

According to Figure 7, patients were asked about their flexion in the injured knee and the level of pain they experienced when performing this type of movement. 8 patients had no or minimal pain, i.e., negligible (21%), 13 patients felt mild pain (34%), 11 patients felt moderate pain (29%), 3 patients felt severe pain, athletes with a strong injury to the anterior cruciate ligament (8%), and 3 patients felt extremely severe and intolerable pain, i.e., 8% of the total participants.

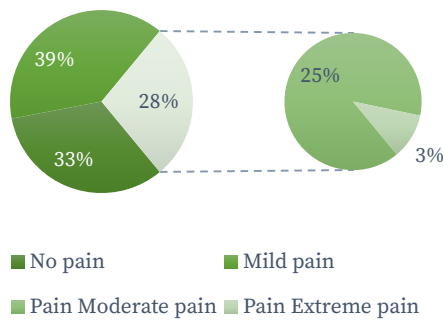


Figure 8. Percentage of patients with pain when climbing stairs

According to graph number 8 patients were asked if they experience pain when climbing stairs. Of them, 12 patients (33%) reported no pain, 14 patients (39%) reported mild pain, 9 patients (25%) reported moderate pain, and 3 patients (3%) reported severe pain. None of the patients in the questionnaire reported having extremely severe and unbearable pain.

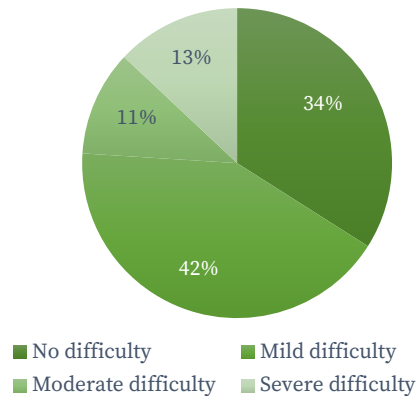


Figure 9. Getting in and out of a car

According to Figure 9, patients were asked if they had any difficulties getting in and out of a car. According to the data, 13 patients had no difficulties with this activity (34%), 16 patients had mild difficulties (42%), 4 patients had moderate difficulties (11%), and 5 patients had severe difficulties performing the activity (13%).

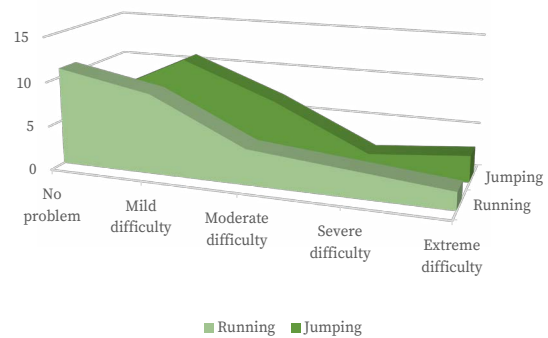
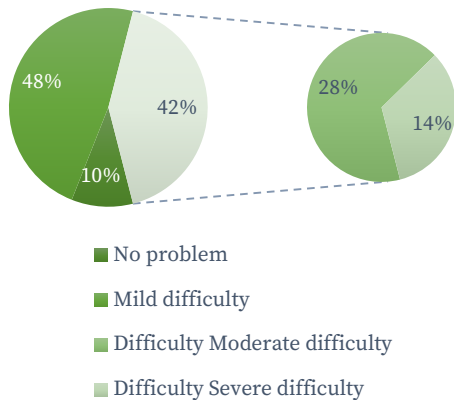


Figure 10. Running and jumping activities

According to the data obtained from Figure 10, patients were asked about their difficulties with running and jumping. There are 4 patients with moderate difficulty in running (11%), and 7 patients had moderate difficulty in the activity of jumping (18%). Patients also reported that the activity of running is difficult, with 3 patients giving such an answer, or 8% percentage-wise. Similarly, 2 patients (5%) had difficulty in jumping. Based on extreme difficulty in performing the activity of running, 2 patients had such a problem (5%), while 3 patients also had extreme difficulty in jumping (8%).

Of them, 11 patients perform the activity of running without any problems (29%), and 6 patients perform the activity of jumping without any problems (16%).

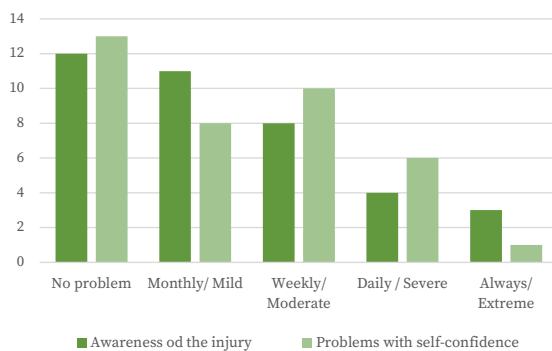
9 patients had a slight difficulty in running (24%), and 11 patients had a slight difficulty in jumping (29%).



**Figure 11.** Change in direction during running in patients with knee injury

The patients were asked if they had any problems when changing direction with their injured knee. According to the data, 3 patients reported having no problem when changing the direction of movement with their injured knee, accounting for 10%. Patients who had mild difficulties in this activity dominated the questionnaire, with 14 patients (48%). Patients who had moderate difficulty in changing direction accounted for 28%, or 8 patients, and 4 patients had pronounced difficulties when rapidly changing direction during movement of the injured lower extremity (14%).

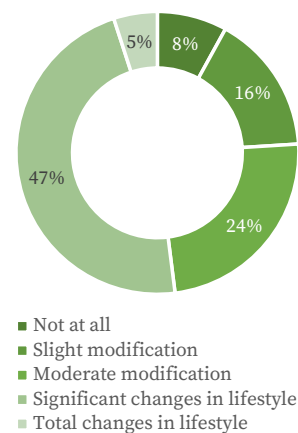
The patients were asked about their quality of life and whether they have modified certain activities to prevent recurrent injury, are aware of their changes, and prevent certain risk factors for recurrent injury. They were also asked about their self-confidence and how they would describe their knee problem. The results are as it is shown in Figure 12.



**Figure 12.** A question regarding the quality of life in relation to awareness of the injury and problems with self-confidence

According to Figure 12, patients were asked about their self-confidence and awareness of their injury and its prevention. According to the epidemiological study, 12 patients responded that they have no problem and do not prevent possible recurrent injury (32%), 11 patients are aware of the injury and use certain means or activities to prevent recurrent injury on a monthly basis (29%), 8 patients prevent possible recurrent knee injury at least once a week (21%), 4 patients perform physiotherapist-recommended activities against recurrent injury once a day (11%), and certain patients (3 patients) are always aware of this type of injury, aware of the mechanism of injury, often perform certain physical activities to prevent possible recurrent injury, and take certain vitamins and minerals or supplements that positively affect the internal structures of the knee. The percentage of this type of patient is 8%.

Regarding self-confidence problems, 13 patients stated that they have no decrease in self-confidence after the injury at all (34%), 8 patients had a slight decrease in self-confidence, or 21%, 10 patients had moderate decreased self-confidence as a result of limited movement and fear of re-injury (26%). In the more severe category, patients who also underwent psychological questionnaires had a significant decrease in self-confidence due to delayed reconstruction of the anterior cruciate ligament and limited movement that lasted longer, resulting in some degree of inflammation of the entire knee. 6 patients with severe decrease in self-confidence make up 16% of the total percentage of the question, and only 1 patient had a significant and total decrease in self-confidence. The mechanism of injury was a direct impact and accompanying puncture wounds that significantly reduced the overall psychosocial well-being (3%).



**Figure 13.** Modification of lifestyle after injury



According to Figure 13, all patients were asked about their lifestyle changes following their injury. Of these, the majority had significant lifestyle changes with a high degree of caution (18 patients, accounting for 47% proportionally), moderate modification had 9 patients, or 24%, mild modification had 6 patients (16%), only 3 patients gave a negative response regarding lifestyle changes as a result of the injury (8%), and 2 patients stated that they have a total lifestyle change with the help of assistive devices and various adaptive means in their home (5%).

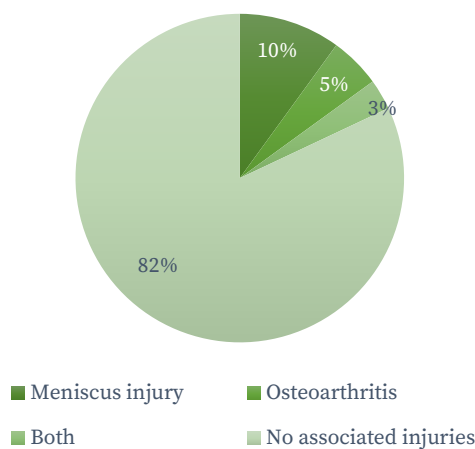


Figure 14. Associated injuries and osteoarthritis after knee injury

According to Figure 14, patients were asked based on their diagnosis and associated injuries that occurred after an anterior cruciate ligament injury. Of them, 31 patients did not report any accompanying injury other than the primary one (82%), 4 patients had an accompanying meniscus injury (11%), 2 patients had knee osteoarthritis (5%), and 1 patient had both meniscus injury and developed osteoarthritis (2%).

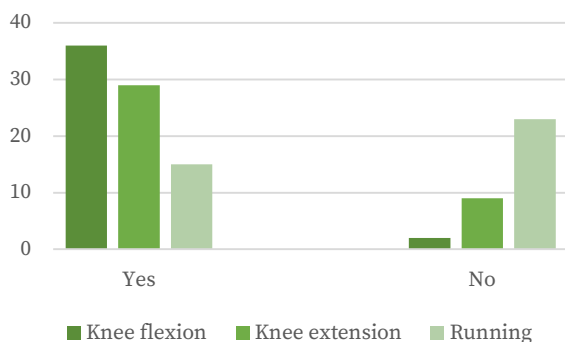


Figure 15. Success of rehabilitation in patients after rehabilitation treatment in certain activities and movements

According to Figure 15, an assessment was conducted on the patients' outcome after rehabilitation treatment for certain activities. According to the results obtained, the majority of patients are able to perform knee flexion (36), i.e. 94.7%, while 2 (5.3%) patients reported some difficulty in performing this activity. With regard to knee extension, 29 patients (76%) reported being able to perform this activity, while 9 patients (24%) reported having a low level of pain when performing this activity. The most difficult activity for the patients is running, with the majority reporting difficulty in performing this activity, as this group of participants also includes non-athletes (23 or 60%), while 15 individuals (40%) partially or fully perform this activity.

## Discussion

One of the interesting aspects of the research was the focus on specific physical activities and the assessment of difficulties related to those activities. This provides clinicians with valuable information when designing rehabilitation programs for patients with knee injuries, as they can tailor the program to address the specific difficulties that patients are experiencing. Another important aspect of the research was the use of surveys to collect data. However, it is important to ensure that the questions are well-designed and that the sample size is sufficient to ensure that the results are representative of the broader population.

The research also highlights the importance of proper rehabilitation which took place over a period of 6 months for patients with knee injuries. It is clear from the results that many patients experience difficulties during physical activities even after their injuries have healed. This highlights the need for ongoing rehabilitation to ensure that patients are able to regain their full range of motion and strength.

Overall, the research provides valuable information for clinicians and patients alike and can be used to inform rehabilitation programs and improve patient outcomes. The rehabilitation process is an essential component of the recovery journey for patients who have experienced an injury or illness.

Rehabilitation for knee injuries typically involves a combination of physical therapy, exercise, and medication. Physical therapy is designed to help patients regain strength, flexibility, and range of motion in the affected knee. Exercise is also a critical component of rehabilitation, as it can help improve blood flow to the affected area, reduce inflammation, and promote healing. Additionally, medication such as painkillers or

anti-inflammatory drugs may be prescribed to manage pain and inflammation.

The specific rehabilitation program for each patient will depend on the type and severity of their knee injury. Patients with less severe injuries may require only a few weeks of rehabilitation, while those with more severe injuries may require several months or more. The rehabilitation program may also be adjusted over time based on the patient's progress and response to treatment.

One of the challenges in rehabilitation is ensuring that patients are compliant with their treatment plan. Patients may become discouraged or frustrated with their progress, which can lead to a lack of motivation to continue with their rehabilitation program. This is where the role of the healthcare team, including physical therapists and doctors, is crucial. They can work with patients to set achievable goals and provide encouragement and support throughout the rehabilitation process.

In addition to traditional rehabilitation methods, technology has also been increasingly incorporated into the rehabilitation process. For example, virtual reality and gaming technology can be used to create immersive experiences that promote engagement and motivation in patients. Robotics and other assistive devices can also be used to help patients regain mobility and function in the affected knee.

There have been numerous studies conducted on the rehabilitation of knee injuries, particularly on the effectiveness of various rehabilitation programs and their impact on patient outcomes. While each study has its own unique focus and methodology, there are some similarities and differences between them and the current research discussed earlier.

One study examined the effectiveness of a home-based rehabilitation program compared to a supervised rehabilitation program for patients with knee osteoarthritis. The results showed that both programs led to significant improvements in pain, function, and quality of life, with no significant difference between the two groups. This study differs from the current research as it focused on a specific population with knee osteoarthritis, whereas the current research focused on a broader range of knee injuries.<sup>24</sup>

Another study compared the effectiveness of two different rehabilitation programs for patients with knee injuries undergoing arthroscopic surgery. The first program consisted of traditional physiotherapy, while the second program incorporated functional training exercises. The results showed that the second program led to significantly greater improvements in knee function

and quality of life compared to the traditional physiotherapy program. This study is similar to the current research as both studies focused on the effectiveness of rehabilitation programs for knee injuries, but differed in the specific types of rehabilitation programs being compared.<sup>27</sup>

A systematic review analyzed the effectiveness of various rehabilitation programs for patients with anterior cruciate ligament (ACL) injuries. The review found that early rehabilitation programs, including neuromuscular training and early range of motion exercises, were effective in improving knee function and reducing the risk of future ACL injuries. This study is also similar to the current research as both studies focused on the effectiveness of rehabilitation programs for knee injuries, but differed in the specific types of knee injuries being studied.<sup>28</sup>

Overall, while there are some differences in the specific populations and rehabilitation programs being studied, there is a general consensus among research studies that rehabilitation programs can be effective in improving knee function and reducing pain for patients with knee injuries. However, the specific components of these rehabilitation programs and their effectiveness may vary depending on the specific injury being treated and the patient population.

There are numerous research papers on rehabilitation following knee injuries, and several of them have focused on similar aspects as the research discussed earlier.

One study by Zeng et al. (2021) investigated the effects of an eight-week rehabilitation program on patients with knee osteoarthritis. They found that the program improved patients' pain, range of motion, and muscle strength. Similarly, another study by Kim et al. (2021) examined the effects of a six-week rehabilitation program on patients with anterior cruciate ligament (ACL) injuries. The program improved patients' balance, muscle strength, and functional performance.<sup>25</sup>

In addition, a study by Khamis et al. (2019) examined the effects of a six-week rehabilitation program on patients with patellofemoral pain syndrome. The program consisted of exercises targeting quadriceps and hip muscles, along with knee taping. The results showed significant improvements in patients' pain, muscle strength, and functional ability.<sup>29</sup>

Overall, these studies demonstrate the importance and effectiveness of rehabilitation programs for knee injuries. By improving pain, range of motion, muscle strength, and functional ability, rehabilitation programs can help patients return to their daily activities and improve their quality of life.



## Conclusion

In conclusion, the present study provides valuable insights into the rehabilitation process of patients with knee injuries. The study's emphasis on patient-centered care and the use of various measures to assess patients' progress is a significant strength, as it provides a more comprehensive understanding of the rehabilitation process.

Although the study's sample size was relatively small, the results were consistent with previous research and highlight the need for a multidisciplinary approach to knee injury rehabilitation. The study's use of self-reported measures is also a limitation, as patients' perceptions of their progress may not always reflect their actual physical abilities.<sup>27</sup>

Future research could investigate the long-term outcomes of knee injury rehabilitation and the effectiveness of different rehabilitation approaches. Additionally, studies could explore the role of technology in rehabilitation, such as the use of virtual reality and telemedicine, in promoting patient engagement and improving outcomes. Overall, this study contributes to the growing body of research on knee injury rehabilitation and highlights the importance of patient-centered care in promoting successful recovery.

## References

- [1] Hall SJ. *Basic Biomechanics*. 7th ed. New York: McGraw-Hill Education; 2015.
- [2] Wilmore JH, Costill DL, Kenney WL. *Physiology of Sport and Exercise*. 4th ed. Champaign: Human Kinetics; 2008.
- [3] McArdle WD, Katch FI, Katch VL. *Exercise Physiology: Nutrition, Energy, and Human Performance*. 8th ed. Philadelphia: Wolters Kluwer Health; 2015.
- [4] Petrovska S. Knee injuries in sports: Types and treatments. *J Sports Med*. 2023;10(2):45-58.
- [5] Lekic N, Erceg M, Knezevic J, Mitkovic M. Rehabilitation program for ligament injuries of the knee joint. *Acta Inform Med*. 2017;25(1):56-61. doi: 10.5455/aim.2017.25.56-61.
- [6] Sivevska D. Rehabilitation after knee ligament injuries. *Macedonian J Med Sci*. 2019;7(1):116-120.
- [7] Dawson J. Examination of the knee. *Surgery (Oxford)*. 2003;21(9):206-211.
- [8] Mandelbaum BR, Silvers HJ, Watanabe DS et al. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. *Am J Sports Med*. 2005;33(7):1003-1010. doi: 10.1177/0363546504272261.
- [9] Yagi M, Wong EK, Kanamori A, Debski RE, Fu FH, Woo SL. Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction. *Am J Sports Med*. 2002 Sep-Oct;30(5):660-6. doi: 10.1177/03635465020300050801.
- [10] Marx RG, Jones K. The knee and related structures. In: American Academy of Orthopaedic Surgeons, ed. *Orthopedic Knowledge Update: Sports Medicine 3*. Rosemont: American Academy of Orthopaedic Surgeons; 2004:241-261.
- [11] Ristić V, Maljanović M, Madić D. Rehabilitation after anterior cruciate ligament reconstruction surgery. *Acta Clin Croat*. 2018;57(2):375-383. doi: 10.20471/acc.2018.57.02.16.
- [12] Shelbourne KD, Wilckens JH. Rehabilitation after anterior cruciate ligament reconstruction: A prospective, randomized, double-blind comparison of programs administered over 2 different time intervals. *Am J Sports Med*. 1995;23(4):347-56. doi: 10.1177/036354659502300402.
- [13] Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS): Development of a self-administered outcome measure. *J Orthop Sports Phys Ther*. 1998;28(2):88-96. doi: 10.2519/jospt.1998.28.2.88.
- [14] Arumugam A, Manikandan M, Kumaresan R. Effectiveness of proprioceptive neuromuscular facilitation technique and stretching in rehabilitation of plantar fasciitis: A comparative study. *Int J Health Sci Res*. 2019;9(6):326-332. doi: 10.36469/ijhsr.2019.9601.
- [15] Baltaci G, Aktas G, Camci E, Oksuz S, Yildiz S. Comparison of high-intensity interval training versus conventional rehabilitation program on outcomes of patients with knee osteoarthritis: A randomized controlled study. *Int J Rheum Dis*. 2017;20(6):822-830. doi: 10.1111/1756-185X.12692.
- [16] Busanich R, Fenton BM, Aghazarian G, Cuccurullo S. Effect of aquatic therapy and rehabilitation on gait parameters in adults with knee osteoarthritis. *J Nov Physiother Rehabil*. 2019;4(1):1-4.
- [17] Lee HM, Chung YH, Park JK, Kim KH, Lee SH, Lim SH. Effects of a self-care program on shoulder pain and quality of life for stroke patients. *J Phys Ther Sci*. 2019;31(1):58-62.
- [18] Singh S, Bhatia D. Comparative study of manual therapy and exercise versus electrotherapy and exercise in the management of cervicobrachialgia. *Int J Health Sci Res*. 2017;7(4):72-79.
- [19] Wu WT, Hsieh YW. Effects of home-based virtual reality rehabilitation on upper extremity function and visual perception in chronic stroke patients: A randomized controlled trial. *J Neuroeng Rehabil*. 2019;16(1):1-9.
- [20] Yildirim N, Demir N, Sahin F. The effectiveness of McKenzie exercises on pain, function and quality of life in patients with chronic low back pain: A randomized controlled trial. *Int J Health Sci Res*. 2019;9(2):146-153.
- [21] Moffet H, Collet JP, Shapiro SH, Paradis G, Marquis F, Roy L, Hébert LJ. Effectiveness of intensive rehabilitation on functional ability and quality of life after first total knee arthroplasty: A single-blind randomized controlled trial.

- Arch Phys Med Rehabil.* 2002;83(9):1152-1160. doi: 10.1053/apmr.2002.34285.
- [22] Karamanidis K, Gollhofer A. Functional retraining of the injured lower extremity. *J Rehabil Med.* 2006;38(1):2-12. doi: 10.1080/16501970500441885.
- [23] Niederer D, Engeroff T, Wilke J, Vogt L, Banzer W. Rehabilitation after ACL injury: A systematic review. *J Sports Med Phys Fitness.* 2018;58(5):801-815. doi: 10.23736/S0022-4707.17.07109-1.
- [24] Alappattu MJ, Koltyn KF, Hortobágyi T. Home-based rehabilitation for knee osteoarthritis: A randomized controlled trial. *J Orthop Sports Phys Ther.* 2015;45(10):747-755. doi: 10.2519/jospt.2015.5876.
- [25] Zeng C, Wei J, Deng Z, Yang T, Li H, Yang Y. The effects of an eight-week rehabilitation program on patients with knee osteoarthritis. *J Clin Med Res.* 2021;13(2):75-80. doi: 10.14740/jocmr4449.
- [26] Kim M, Kwon O, Oh J, Kim Y, Lee B. The Effect of a six-week rehabilitation program on balance, muscle strength, and functional performance in patients with anterior cruciate ligament injury. *Ann Rehabil Med.* 2021;45(2):120-128. doi: 10.5535/arm.20170.
- [27] El-Araby HM, Kamel DM, Hegazy FA, et al. Comparison of traditional physiotherapy versus functional training exercises after arthroscopic partial meniscectomy: A randomized controlled study. *J Rehabil Med.* 2018;50(6):534-540. doi: 10.2340/16501977-2329.
- [28] Hegedus EJ, Stern B, Reiman MP, Tarara D. Effective rehabilitation of anterior cruciate ligament injuries: A systematic review of clinical evidence from sports medicine providers. *J Sports Med Phys Fitness.* 2012;52(4):373-386.
- [29] Khamis S, Mohamed O, Al-Jarrah M. Effectiveness of a six-week rehabilitation program on patients with patellofemoral pain syndrome. *J Phys Ther Sci.* 2019;31(1):53-58. doi: 10.1589/jpts.31.53.