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The Impact of Exercise-Based Rehabilitation on ACL Patients: A Comprehensive Review in the Context of China's Healthcare System

Haojie Dai[1] and Faridah M.Said[2]

Abstract

This journal review investigates the effectiveness of exercise-based rehabilitation in assisting ACL patients to return activity level. The main objective of this review is to analyze how exercise-based rehabilitation influences recovery for ACL clients within a Chinese healthcare system. The specific exercise-based rehabilitation that were investigated as part of the study included Nordic, hamstring exercises, aquatic workouts; suspension training and lastly eccentric isokinetic. The outcome factors for ACL healing were improved muscle strength and proprioception, remarkable functional stability levels, regain of full range of motion as well free of pain and reduced risk to re-injury. The retrieval of relevant scholarly sources were gathered from extensive use online databases and publications. The results of the research showed that exercise rehabilitation programs contributed to successful treatment of ACL injuries in Chinese patients. The literature has indicated that aquatic exercises and Nordic hamstring have proved to be successful in enhancing the muscle strength, proprioception among Chinese ACL patients. In addition, suspension training led to the improvement of functional stability and return-to play. Secondly, the study results indicated that rehabilitation training was appropriate for relieving pain and enhancing ROM in people with ACL injuries. Lastly, eccentric kinetic exercise was proven effective in decreasing the chances of re-injury and as a physical activity post injury. Recommendations in the study include targeted exercise-based rehabilitation therapies, and as required instituting combined exercise treatment among patients with ACL.

Keywords: *Rehabilitation, Exercise, China, Healthcare, ACL, Patients, China.*

INTRODUCTION

ACL injury is a common primary ligament injury in active sports and it has been documented that as many as 2000 suffer from these knee injuries only for Hong Kong (Ong et al., 2024). Ideally, the anterior cruciate ligament consists an essential part of a knee structure that plays indispensable role in kinematics to avoid loads and translation by anterolateral tibia. (Saki et al., 2023). In a similar fashion, ACL rehabilitation has been found to decrease varus and lateral rotation stresses. ACL injury is considered an essential and complex neurophysiological dysfunction challenge that affects the functionality and range of motion and increases the risk of re-injury among sports athletes (Ong, 2024). Given its complexity within the kinematics, ACL-based injuries contribute to both subjective instability and potential clinical signs such as pain, which calls for the need for rehabilitation. As explained by Saki et al. (2023), ACL injuries are known to be very common among athletes. Accordingly, these injuries could range from mild, for example, sprain/minor tears, to severe cases where one could encounter a complete torn of the ligament (Saki et al., 2023). A total rapture and torn ACL require a surgical reconstruction to be performed. However, it is only sometimes guaranteed that surgical reconstruction can help the athlete regain the capability to attain their previous activity level (Ong, 2024). ACL rehabilitation is always conducted for surgical options and conservative purposes.

[1] Doctor of Philosophy (Ph.D.) in health Science Faculty of Applied Science, Lincoln University College Malaysia E-mail: 286125058@qq.com

[2] Professor of Nursing Studies Faculty of Applied Science, Lincoln University College Malaysia E-mail: faridah.msaid@lincoln.edu.my

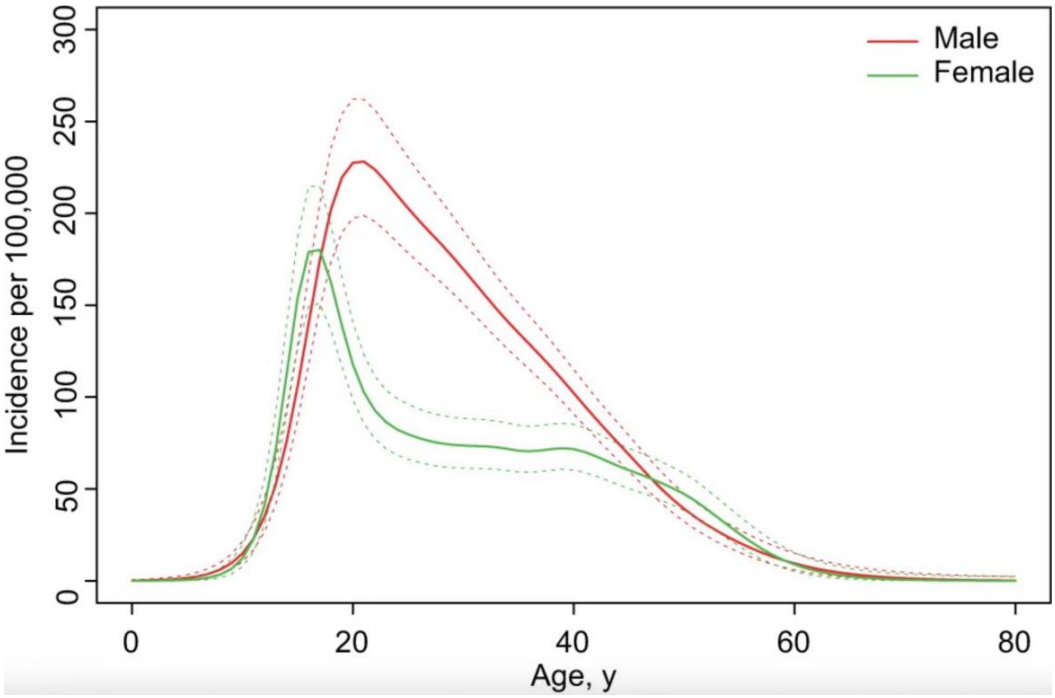

Figure1 Incidence of anterior cruciate ligament (ACL)

The anterior cruciate ligament (ACL) is a dense connective tissue band that courses to the tibia from the femur (Glattke et al., 2022). ACL stems from the posteromedial medial aspect corner within the condyle lateral femoral. It is important to note that the ACL courses medially, anteriorly, and distally across the joint as it stems from the femur to the tibia (Glattke et al., 2022). The blood vessel density within the ACL ligament is not often homogenous. The poor healing of the ACl-related injuries results from the presence of fibrocartilage and poor vascularity coincidence, which cause gliding tendons during a compressive force. According to Glattke et al. (2020), the ACL is one of the most critical ligaments that help stabilize the knee joint. In this case, the ACL connects the tibia and the femur and provides a practical and functional range of motion. Nonetheless, it has been established that in most cases, the ligament tends to get injured or torn during changes in direction or sudden stops (Saki et al., 2023). The common symptoms experienced on an injured ACL comprises known swelling, pain, restricted movement, and notable discomfort.

The significance of rehabilitation measures and strategies in ACL injury patients have been noted he past decades. The various research measures have paved the way to more advanced and better rehabilitation measures, including modern forms of exercise. ACL rehabilitation is essential as it provides surgical recovery and conservative treatment (Gokeler et al., 2022). The ACL injury rehabilitation could be vital for conservative treatment for passive clients. Accordingly, it is important to consider the sporting activities, age, and subjective inability signs when developing rehabilitation programs for ACL injury patients (Zang et al., 2022). The most appropriate rehabilitation program helps ACL-injured individuals regain their functionality, activity level, range of motion,, and muscle strength (Li et al., 2022). However, it is essential to consider anterior cruciate ligament reconstruction, especially during poor adjustment or symptomatic instability (Gokeler et al., 2022). Accordingly, this may prevent various rehabilitation measures as there could be greater possibilities for cartilage and meniscal damage. Other injuries, such as bone contusions and microfractures often influence the management of ACL injuries. Thus, the ACL rehabilitation programs must consider the multiple commodities related to injuries in the ACL (Liu et al., 2023). Most importantly, ACL rehabilitation is paramount as it helps to gain full knee range of motion, repairable strength, and proprioception achieve functional stability, decrease the risk of re-injury, and effectively return to sports activity (Saki et al., 2023).

In China, ACL injuries have a significant prevalence, especially among athletes (Chan et al., 2021). The prevalence of noncontact ACL injury in China is estimated to be approximately 74.6%, as per a study by Jiang

et al. (2023). Every year, the prevalence of ACL keeps increasing, with significant implications for the health and well-being of individuals as it impairs mobility and knee functionality (BAI et al., 2022). In China, managing and rehabilitate ACL injury patients managing and rehabilitating ACL injury patients has become a significant problem. Among the Chinese population, there is a reported elevated prevalence of concomitant intra-articular ACL-related injuries compared to Indians and Malaysians (Chan et al., 2021). Also, in this case, the prevalence of ACL is higher in basketball and soccer games than in basketball. The current study investigates the impact of exercise-based rehabilitation on the recovery of ACL injury patients (Hu et al., 2023). The review mainly focuses on the context of the Chinese Healthcare system to gather insights on how practical exercise-based programs arerams in ACL injuries. The vital hypothesis in this study is that exercise-based rehabilitation is effective in gaining various aspects of rehabilitation within ACL injury patients (Li et al., 2022). Ideally, the study explains the effectiveness of different exercise-based rehabilitation methods among ACL patients (Li et al., 2022). It is expected that exercise-based rehabilitation is essential among ACL patients as it helps to foster functional stability, regain muscle strength and proprioception, reduce the risk of pre-injury, promote a range of motion, and encourage a return to optimal sport level (Li et al., 2022).

LITERATURE REVIEW

ACL Injuries and the Chinese Healthcare Context

The anterior cruciate ligament (ACL) is an example of a frequent orthopedic knee injury seen within Chinese clinical practice settings (Chan et al.,2021). As Chan and colleagues note, most ACL injuries are associated with chondral lesions and concomitant meniscus within the knee. It is worth noting noting that during the 1990s, ACL was identified as one of the significant threats within the sports world and hence gained attention (Parsons et al., 2021). ACL injuries have been a critical problem, especially among females than males. For instance, over the past two decades, females have been reported to be 3 to 6 times more likely to record ACL injury as compared to females (Parsons et al., 2021). There is a moderately high prevalence of ACL injuries among Chinese populations, especially among athletes. As explained by Chan et al. (2021), the Chinese population reports an elevated prevalence of concomitant intra-articular ACL-related injuries compared to Indians and Malaysians. In the same case, the most common contributing factors of ACL among the Chinese population comprises sports activities, including football, netball, and basketball. However, basketball and soccer were identified as major contributing factors to ACL netball (Chan et al., 2021). According to BAI et al. (2022), the prevalence of ACL in China is known to increase. ACL-related injuries are known to impair individual mobility and knee functioning, affecting their health and well-being (BAI et al., 2022). For instance, it reduces an individual's optimal capability and involvement within games as it limits their sports engagement. With a prevalence of 74.6%, ACL noncontact injuries present an important clinical health problem within the Chinese healthcare system (Jiang et al., 2023). It is worth noting that having high-grade fracture subtypes presents unique challenges that make them challenging to address.

Exercises-Based Rehabilitation Practices in ACL Injuries

Several exercise-based rehabilitation strategies have been documented to help address challenges related to ACL injuries. The notable exercise-based exercises known to help in ACL injuries include Nordic hamstring exercise, aquatic exercise, suspension training, rehabilitation training, and Isokinetic exercise, also referred to as the accommodating variable resistance. The treadmill The aquatic exercise also called the water treadmill walking exercise, is an important ACL exercise that promotes muscle strength and endurance (Li et al., 2022). The treadmill water exercise offers an important combination of mobilizing injured joints or stiffs and reducing weight bearing. The Nordic hamstring exercise is practiced when an individual kneels through their feet within a fixed position and lowers their body through the knee extension (Chen et al., 2023). Nordic hamstring is a necessary approach that helps foster muscle strength and effectively regain range of motion while reducing the risk of an ACL injury. Suspension training (SET) is a neuromuscular exercise that enables the body to undertake active training through joint motion training, muscle relaxation training, sensory and motor coordination, joint stability training, and muscle potential energy training (Huang et al., 2021). The SET exercise-based rehabilitation approach has been identified as crucial to help attain individual functionality while experiencing ACL injury. Rehabilitation training is an important exercise that helps strengthen muscles and help to achieve

functionality through resistance, body weight, and therabands (Yang et al., 2021). The isokinetic exercise is often conducted with a muscle force that matches the resistance at speed movement (Ong et al., 2024). CommonCommon isokinetic exercises include leg curls, leg extensions, push-ups, stationary cycling, dumbbell shoulder press, and squats (Ong et al., 2024). Ultimately, speed is made constant with the isokinetic exercises while the resistance keeps varying. The aforementioned exercises can be combined or implemented independently with other medical interventions to help achieve optimum recovery among ACL patients. However, some studies argue that exercise-based rehabilitation exercises are ineffective in achieving optimal ACL recovery (Glattke et al., 2022). Thus, this study suggests the need to correctly select the choice of rehabilitation exercise for the most appropriate ACL injury and its related commodities. For instance, Glattke et al. (2022) report that high-intensity high-intensity exercises are not relevant to effectively reconstructing ACL injury. Nonetheless, the study explains that accelerated rehabilitation is essential to help attain recovery, particularly for clients with semitendinosus-gracilis grafts in the reconstruction of the ACL (Bregenhof et al., 2023). Glattke et al. (2022) highlight the importance of early rehabilitation via structured training to accomplish recovery in ACL patients. For example, it was observed that the treatment of ACL injury using plyometric exercise at high intensity is not effective; however, chain kinetic exercises are applied early (Glattke et al., 2022). Therefore, exercise-based rehabilitation should be controlled and appropriately customised in a timely manner to achieve effectiveness.

Challenges and Opportunities in the Chinese Healthcare Context

There are many challenges and opportunities surrounding ACL injuries in Chinese healthcare (Uchino et al., 2022). For instance, there are limited clinical standards and guidelines in China that describe the choice of optimal surgical plans, rehabilitative resources, and treatment options for patients with ACL injuries (BAI et al., 2022). As a consequence of which, it is rather difficult to determine the ideal exercise-based rehabilitation program that will help achieve maximum results in ACL injury healing within patients. The second main issue discussed is that the tibial footprint size in Chinese population is smaller than ACL from western populations (Li et al., 2020). Therefore, such a unique anatomy implies that the Chinese population has higher chances of suffering from ACL tear or poor recovery (Gamble et al., 2021). Thus, this needs to be thought about in great detail with Chinese population from rehabilitation or treatment point of view (Li et al., 2020).

Chinese exploration and research of ACL rehabilitation exercise mechanisms presents an opportunity to address the ACL injury recovery problems (Fernandes et al., 2022). Empirical studies have shown that several exercise-based rehabilitation regimes brings the benefits of perfect modifications to treatment in ACL individuals (Huang et al., 2023). Choosing the correct combination of exercise-based rehabilitation measures along with other medical methods provides an opportunity to efficiently deal with ACL injuries' problems and consequences in Chinese patients (Khan et al., 2024).

THEORETICAL FRAMEWORK (THEORY OF PLANNED BEHAVIOR)

The investigation of the efficacy of various exercise-based rehabilitation strategies in ACL recovery can better be understood using the TPB theory (Petushek et al., 2019). The physical rehabilitation intervention aids ACL patients in the reduction of pain and swelling, muscle strength and proprioception improvement improve motion range as well as return-to-sport is participation physical exercise (Kleis et al., 2021). Thus, the most appropriate exercise-based rehabilitation should be administered to affected patients in order for optimal recovery outcomes and minimizing other secondary health burdens (Bezerra et al., 2022). Nonetheless, there exist factors that may affect the participation of ACL patients in physical exercise, which TPB can explain better (Culvenor et al., 2022). For instance, psychological influencers such as low self-efficacy and being afraid of re-injury can decrease ACL patient participation in physical exercise rehabilitation (Kleis et al., 2021). Beliefs and attitudes regarding exercise-based rehabilitation motivational components social support, sociodemographic factors can affect involvement of ACL patients in rehabilitation exercise (Nelson et al., 2021). The theory provides an understanding of why it is necessary to realize what influences various ACL patients and take such considerations in designing appropriate rehabilitation exercises (Kleis et al., 2021). The TPB details that individual health behaviors are controlled by the personal intentions of individuals, formed out of three aspects: subjective norms, attitudes and perceived behavior control (Stephenson et al., 2021). Their readiness to embrace

exercise-based rehabilitation determines the attitude of patients toward its utilization. Thus, patients' attitude should be evaluated and it must have been very positive to allow better results in terms of exercise-based rehabilitation program (Lee et al., 2023). In the same way, social norms influence rehabilitation exercise as it is influenced through peer pressure. The utilization of rehabilitation exercises among ACL patients could encourage physical therapists and peers towards better recovery (Lee et al., 2023). Lastly, perceived behavioral control should influence the optimum use of rehabilitation exercises. In this case, it is crucial to improve the self-efficacy of the ACL patients while also ensuring the environment is conducive and resources are available. Accordingly, the TPB provides an overview of the effectiveness of exercise-based rehabilitation and guides the designation of the most appropriate exercise-based rehabilitation for

ACL patients.

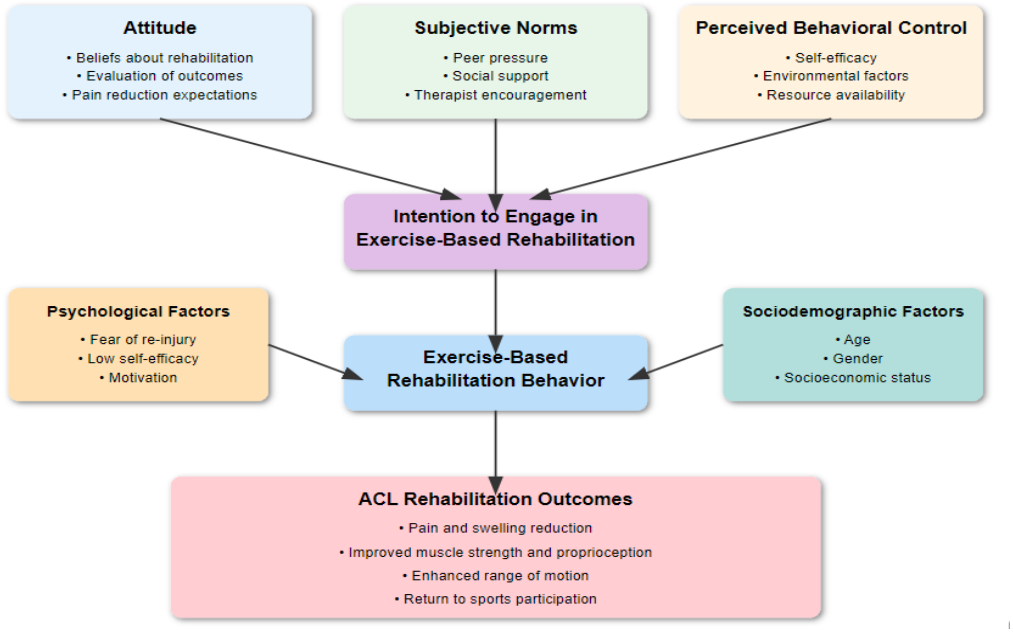

Figure 2 The theoretical framework of the study

METHODOLOGY

First, an extensive search was conducted on popular and credible academic publications and online databases to help identify and retrieve relevant sources for the current study. The keywords used to conduct the comprehensive search include Exercise, Rehabilitation, China, Healthcare, Patients, Anterior cruciate ligament, and China. Filtering ensured that only recently published articles within the age of 5 years were published. Using the recent study was to maintain relevancy and improved accessibility.

After the retrieval of articles, high-quality criteria were designed to ensure relevance, credibility, and valid choice of articles to be used in the study. The choice of articles was only validated by their ability to address the use and effectiveness of exercise-based rehabilitation among ACL patients, particularly in the Chinese population. The studies that did not meet the desired topics were discarded.

Thirdly, data from the articles were extracted and compiled within a central database. Important study aspects that were polled together comprised the author names, study aim, publication year, abstracts, designs, methodologies, and results. This was a vital step towards enabling important comparison and review of the studies.

The analysis of the study findings was based on a thematic analysis of the important outcome variables of improved ACL recovery. The desired outcome variables indicated enhanced ACL recovery improved muscle

proprioception and muscle strength, better range of motion and reduced pain, elevated functional stability, and reduced risk of re-injury. From the analysis, a critical discussion of similarities and comparisons with other studies was conducted. Also, early rehabilitation and the correct choice of rehabilitation exercise among ACL patients were explained.

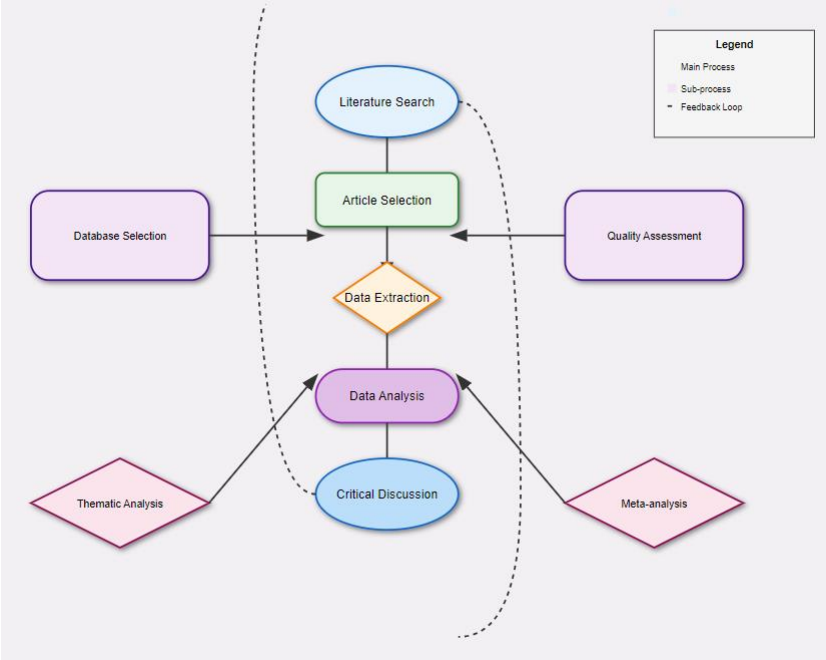

Figure 3 The methodology design of the study

RESULTS AND DISCUSSION

Regaining Muscle Proprioception and Muscle Strength

A Chinese-based single-blind, randomized, and prospective clinical trial by Li et al. (2022) established that exercise-based rehabilitation is effective in ACL injury patients as it promotes muscle strength, knee performance, and proprioception. In this study, the exercise-based rehabilitation used is water-based treadmill walking (aquatic exercise). The clinical trial showed that after three weeks of exercise, there was a notable improvement in knee performance, muscle proprioception, and muscle strength (Li et al., 2022). Thus, the study agrees that rehabilitation exercise is the most appropriate approach to attaining muscle strength and proprioception among ACL injuries after 6 to 24 weeks. Also, another China-based control clinical trial by Chen et al. (2023) showed that the application of Nordic hamstring exercises is known to help improve hamstring and quadriceps muscles by 85% and 75%, respectively. Ideally, the study adds that the approach is Accurate, safe, and practical,, especially after patients have experienced ACL reconstruction. The two Chinese studies align with the work of Forelli et al. (2023) that, indeed, exercise-based rehabilitation is vital to helping foster muscle strength and proprioception among ACL patients. The study relates that between 3 and 6 months, exercise rehabilitation measures such as kinetic chain exercises are effective in fostering hamstring and quadriceps muscle strength.

Excellent Functional Stability

A Chinese-based work by (Huang et al. (2021) notes that exercise-based rehabilitation approaches, such as Suspension Training, are effective in attaining excellent functional stability among patients with ACL injuries. Huang et al. (2021) reported after six weeks, it is noted that dynamic and static balance operational stability was improved after the SET intervention. The improved operational stability is attained from local stabilization, coordination, and control of muscles through SET's safe and practical training. Most importantly, functional

stability is achieved after therapy with improved muscle strength within the hamstring and quadriceps muscles (Huang et al., 2021). The findings from this Chinese study alignwith the work of Hosseini Khah et al. (2023), which also found that six-weekuspension training is an effective form of exercise in attaining optimal functional stability among ACL injury patients. In addition, the authors relate that using suspension training exercises improves the performance and ability of the athletes to return to their optimal level without the fear of re-injury.

Gaining Full Knee Range of Motion (ROM) and Reducing Pain

Exercise-based rehabilitation including rehabilitation training is sufficient enough to manage pain and attain the full range of motion among ACL injury patients in a Chinese setting (Yang et al., 2021). According to Yang et al. (2021), it is found that after three months of rehabilitation training, there is a significant improvement in joint motion and, hence, improvement in the range of motion. In the same case, after days 3, 7, and day 14, pain was significantly reduced following the rehabilitation training exercise (Yang et al., 2021). As noted by Yang and colleagues, swelling and pain were reduced considerably after rehabilitation, which explains the improved functionality of joints and, hence, improved motion. Moreover, this study suggests that it is vital to consider early rehabilitation to help attain optimum outcomes among ACL patients. Ideally, this finding aligns with the work of Shu et al. (2022), who agree that rehabilitation exercises effectively achieve optimal range of motion and reduce the experience of pain. Therefore, it is vital to provide rehabilitation training exercises to ACL patients to achieve optimal activity levels as they reduce pain and improve their range of motion.

Reduce Re-Injury

According to a Chinese-study performed by Ong et al. (2024), eccentric isokinetic exercise promotess muscle strength and functional recoveryando improves the risk of re-injury among ACL patients. As per the study, applying the eccentric isokinetic exercises is crucial to help to reduce re-injury by 55.6%. Therefore, this effective rehabilitation exercise seeks to reduce the risk of re-injury as it fosters improved return to sport and daily activities among athletes and individuals. Another study by Vidmar et al. (2020) agrees with Ong and colleagues that, , isokinetic exercises, particularly eccentric exercises, are, are effective in improving return to sport capability and reducing the risk of re-injury during ACL. Ideally, the randomized control trial also adds that using eccentric isokinetic exercises is the safest, most effective approach that aids in building quadriceps muscle strength, which helps reduce the risk of re-injury (Vidmar et al., 2020). Thus, this shows that exercise can help improve athletes' recovery and well-being.

Rehabilitation Objective	Methodology	Intervention	Key Findings	Implications
Restoration of Muscle Proprioception and Strength	Single-blind, randomized, prospective clinical trial in China	Aquatic treadmill walking	Significant improvement in knee performance, muscle proprioception, and strength after 3 weeks	Exercise-based rehabilitation is effective for ACL injury patients 6-24 weeks post-injury
	Controlled clinical trial in China	Nordic hamstring exercise	85% improvement in hamstring and 75% in quadriceps muscle function	Accurate, safe, and practical approach, especially post-ACL reconstruction
	Comparative study	Kinetic chain exercises	Effective enhancement of hamstring and quadriceps strength between 3-6 months	Corroborates findings from Chinese studies on exercise rehabilitation efficacy
Functional Stability Enhancement	Clinical study in China	Suspension exercise training (SET)	Improved dynamic and static balance operational stability after 6 weeks	SET is effective for achieving functional stability in ACL injury patients
	Not specified	Suspension training	Effective for optimal functional stability after 6 weeks	Improves athlete performance and reduces re-injury risk
Range of Motion (ROM) Restoration and Pain Reduction	Clinical study in China	Rehabilitation exercises	Significant improvement in joint mobility after 3 months; pain reduction by day 3, 7, and 14	Early rehabilitation is crucial for optimal outcomes in ACL patients
	Not specified	Rehabilitation exercises	Effective in achieving optimal ROM and reducing pain	Confirms the importance of rehabilitation exercises for ACL patients

Re-injury Risk Reduction	Clinical study in China	Eccentric isokinetic exercise	55.6% reduction in re-injury risk	Enhances muscle strength and functional recovery in ACL patients
	Randomized controlled trial	Eccentric isokinetic exercise	Effective in improving recovery of athletic ability and reducing re-injury risk	Safe and effective method for strengthening quadriceps and reducing re-injury risk

Table 1 The discussion of the study

CONCLUSION

The study results and discussion show that exercise-based rehabilitation exercises are practical in recoverrecoverings within the Chinese context. The different exercise-based rehabilitation programs highlighted have demonstrated significant improvement among ACL injury patients in China. Specifically, the different exercise-based rehabilitation programs have shown effectiveness in improving muscle proprioception and muscle strength, fostering a range of motion and reducing pain, achieving functional stability, and reducing the risk of re-injury. In China, the Nordic hamstring and aquatic exercise help improve muscle strength and proprioception (Li et al., 2022). In the same case, Huang et al. (2021) show that suspension training helps to attain functional stability and improved return to sport capability among ACL patients by improving local stabilization, coordination, and control of muscles. Furthermore, Yang et al. (2021) have showcased that rehabilitation training effectively enhances the range of motion and mitigates pain among ACL patients within the context of the Chinese population. Ong et al. (2024) demonstrate that eccentric isokinetic training reduces re-injury and thus optimal level physical activity or sports return among ACL patients. Thus, the reports have focused on early rehabilitation effectiveness in ACL patients. Thus this means that physiotherapists and other healthcare providers must therefore ensure they prescribe exercise rehabilitation as early as possible for best recovery. Additionally, it has been stated that the success of exercise rehabilitation exercises depends on an appropriate selection of exercise-based therapy. The selection of an exercise for rehabilitation during the disease depends on many key factors, such as some sociodemographic determinants to other issues associated with resources and patient preferences. Researchers may look at individual exercise-based rehabilitation programs to investigate their efficiency and importance in overcoming the issues that ACL patients undergo. It is imperative to investigate the benefits of exercise-based rehabilitation programs in regard to their health implications and possible outcomes with a view towards achieving healthy living and optimum levels wherever applicable. The same also applies to future studies, which must examine what particular exercises and their efficacy regarding various recovery elements among ACL patients.

RECOMMENDATIONS

Provide Targeted Exercise-Based Rehabilitation Measures: In this case, it is crucial for healthcare workers and physiotherapists to evaluate their patients well before they prescribe certain rehabilitation exercises. For instance, it is necessary to evaluate the presence of resources, social factors, distance from training methods and sociodemographic indicators such as gender among other things prior to exercises rehabilitation (Li et al., 2020). Offer rehabilitation exercises that take account of individuals' preferences and beliefs to indicate this as a Chinese context. Moreover, it includes exercises that take into account the fact that the Chinese population has a shorter tibial footprint size yet suffers from ACL. Therefore, this warrants significant attention to the provision of controlled and monitored exercise-rehabilitation measures. More importantly, the type of rehabilitation chosen should be based on the clinical issue that a patient is experiencing. For instance, water exercise and hamstring exercises are recommended to develop muscle strength as well as muscle proprioception issues in ACL injury (Li et al., 2021). On the contrary, range-of-motion and pain issues necessitate selecting rehabilitation training exercises (Huang et al., 2021).

When necessary, administer combined or multiple exercise rehabilitation programs. Applying some exercise-based rehabilitation programs is necessary when addressing ACL-injured patients, and the combination of various therapeutic exercises has been proved to deliver better outcomes in recovery among those who have suffered from an anterior cruciate ligament (Vidamar et al., 20. Using hamstring, Nordic and aquatic exercises can lead to stronger muscle strength and proprioception; increased flexibility range of motion improvement in

the patients while at the same time reducing patient discomfort. Therefore, a controlled mix of rehabilitation enhances the recovery outcomes and best return activity level among ACL patients (Vidamr et al., 2020).

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