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Efforts to reduce the risk of anterior cruciate ligament injury through isometric quadriceps exercise

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ABSTRACT

Anterior cruciate ligament (ACL) injury is one of the most common musculoskeletal injuries in the knee joint. One of the treatments for this injury is reconstruction. Pain is one of the most frequent problems that occur following reconstruction. Isometric quadriceps exercise can be given to reduce pain after phase I reconstruction in patients with ACL injuries. This study was a pre-experimental study with a one group pre and post-test design. This study was conducted in the outpatient room of Bali Royal Hospital Denpasar from March to May 2022. The subjects of this study were 20 patients with ACL injury following phase I reconstruction at Bali Royal Hospital, who met the eligibility criteria of this study. The quadriceps isometric exercise was performed 3 times a week for 4 weeks. Pain was measured using the visual analogue scale (VAS). In this study, the average pain score before and after exercise was 6 ± 1.257 and 3.4 ± 1.046 respectively. The results of data analysis on pain reduction using the paired t-test showed p = 0.000 (p <0.05), it means that there was a significant reduction in pain following isometric quadriceps exercise. It can be concluded that isometric quadriceps exercise can reduce pain in patients following phase I reconstruction of the ACL at Bali Royal Hospital.

Keywords: Anterior cruciate ligament; isometric quadriceps exercise; pain; reconstruction

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INTRODUCTION

Humans as individual and social beings are responsible for maintaining their own lives, and in doing so, humans need optimal physical and psychological health (Muslimin & Hidayat, 2017). Sports and physical activity are some of the ways to improve physical and psychological health (Coenders et al., 2017; Snedden et al., 2018; Andira et al., 2019; Malm et al., 2019; Lankhorst et al., 2019; Kaur et al., 2020). Physical activity is a series of body movements that use power or energy, where the higher the energy expenditure, the higher

the level of activity. However, if carried out excessively, physical activity could increase the risk of injury (Widiyatmoko & Hadi, 2018; Cai et al., 2018; Sollerhed et al., 2020; Baehr et al., 2022).

Injuries related to physical activity and sports are common in the lower limbs. One of the most common lower limb injuries is a ligament tear in the knee, with an incidence rate of 16% (Lambers et al., 2012). The most commonly injured ligament in the knee is the anterior cruciate ligament (ACL) (Gans et al., 2018). The ACL acts as the main stabilizer in the knee joint, which prevents the tibia bone from shifting forward from the femur and controls the rotational movement of the knee (Shen et al., 2018). The incidence of ACL injury occurs in 30-78 people from 100,000 people per year in people aged 10-64 years (Sanders et al., 2016). It has been found that women have a higher risk for an ACL tear than men (Montalvo et al., 2019). ACL injuries are caused by direct or indirect contact to the knee (Sundemo et al., 2019). ACL injuries that are caused by indirect contact or minimal contact occur in 70%-80% of cases, and most frequently occur due to an incorrect landing from a jump, squatting, and sudden twisting and stopping movements (Vacek et al., 2016). Meanwhile, direct contact is often associated with strong valgus pressure along with medial meniscus and medial collateral ligament (MCL) injuries (Acevedo et al., 2014).

ACL injuries can be managed conservatively or through ACL reconstruction followed with rehabilitation from physiotherapy (Filbay & Grindem, 2019). ACL reconstruction with rehabilitation is still considered the primary method of treatment and is highly recommended for someone with severe functional instability of the knee (Van Melick et al., 2016). ACL reconstruction is a surgical procedure that involves the use of a tissue graft to replace the torn ACL. This procedure can be done using two techniques, namely using a hamstring graft by making a small incision in the inferior and medial tibial tubercle to remove the semitendinosus and gracilis tendons using a tendon stripper, or by making a midline incision under the patella to take the patellar tendon and use it to replace the injured ACL. Both of these techniques aim to restore the stability of the knee and joint fixation after ACL injuries (Mouarbes et al., 2019). Problems that often arise in patients following ACL reconstruction are pain, oedema, limited joint motion, decreased muscle strength in the knee, and impaired function and endurance (Gobbi et al., 2016).

The incomplete healing process and lower integrity of the new ligament tissue following ACL reconstruction can cause ligament weakness, which could lead to further injury. Therefore, it is crucial that rehabilitation is carried out in stages (Cavanaugh & Powers, 2017). The stages of rehabilitation post-ACL reconstruction generally consist of 4 phases: the first phase or phase one (I) focuses on minimizing pain and increasing range of motion (ROM); phase two (II) aims to improve strength and neuromuscular control, which includes the development of lower extremity functional strength and improvement of balance; phase three (III) namely the advanced strengthening phase, focuses on increasing the patient's training to plyometrics, agility activities, running and early sport-specific training; and the last phase or phase four (IV) focuses on continuing to improve strength and neuromuscular control with an emphasis on returning to sport activities (Eckenrode et al., 2017). Phase I rehabilitation following ACL reconstruction can be done by providing interventions in the form of exercises, such as isometric quadriceps exercise (Rio et al., 2015). Isometric quadriceps exercise is a form of static exercise that involves the contraction of muscles without any change in muscle length and movement of the joints. This exercise will cause the muscle tension to increase and the muscle length to remain, thereby reducing pain, which is the main problem in phase I after ACL reconstruction (Riel et al., 2018).

A preliminary study conducted at Bali Royal Hospital, Denpasar, Bali found that 165 people underwent reconstruction of the ACL in 2020, and from January to November 2021, there were 157 patients who underwent ACL reconstruction. The majority of patients reported that one of the main problems they experienced following reconstruction was pain. Currently, there is still limited research investigating the effect of isometric quadriceps exercise on pain after ACL reconstruction. In addition, this study presents a novelty in terms of using isometric quadriceps exercise as a way to reduce pain in patients with ACL injuries, because previous studies have only focused on using cross exercises (Papandreou et al., 2009) and squat exercise (Neitzel et al., 2002). This research is important to do because it contributes to scientific insight about the importance of using isometric quadriceps exercise on the ACL, so that becomes an urgency in this research. Based on the findings of our preliminary study and the detrimental effects of post-ACL reconstruction pain if

is not properly managed, we were motivated to conduct this study to determine the effect of isometric quadriceps exercise on pain reduction after phase I reconstruction in patients with ACL injury.

METHOD

This study was a pre-experimental study with a one group pre and post-test design. For more details about the design in this study is presented in Figure 1.

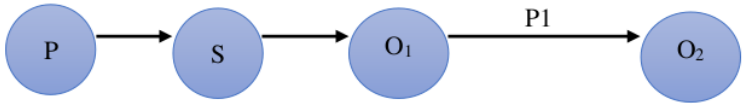

Figure 1. One Group Pre and Post-Test Design

Note:
P = Population
S = Subject
O_1 = Pain score pre-intervention
O_2 = Pain score post-intervention
P1 = Intervention with isometric quadriceps exercise

The sampling method used in this study was non-probability sampling using purposive sampling technique. This study was conducted in the outpatient ward of Bali Royal Hospital, Denpasar, Bali from May to June 2022. The subjects in this study were 20 patients who underwent phase I reconstruction of the ACL at Bali Royal Hospital, Denpasar, Bali. The study included patients aged 17-40 years with good level of consciousness (good orientation to people, place, and time), able to read, write and communicate well, and consented to be participants from the beginning until the end of study by signing an informed consent. The exclusion criteria included patients who have undergone repeated ACL reconstruction (more than once), and patients who experienced complications following ACL reconstruction.

The isometric quadriceps exercise required patients to contract their quadriceps muscle and hold it for 6 seconds, followed by 5 seconds of rest, which was repeated 3 times per session (3 sets of exercise per session). Patients received isometric quadriceps exercise 3 times per week for 4 weeks. The outcome measure used to evaluate pain in this study was the visual analogue scale (VAS), which is a straight or horizontal line 10 cm in length that describes the intensity of pain that is being experienced. It consists of two endpoints marked as "no pain" at one end and "worst pain imaginable" at the other end. Data were analyzed using the Statistical Package for the Social Sciences (SPSS); the analyses performed included normality testing using the Shapiro-Wilk test and hypothesis testing using the paired sample t-test to determine whether there was a significant mean difference in VAS score before and after the intervention (isometric quadriceps exercise).

RESULTS AND DISCUSSION

The following table (Table 1) presents the subjects' characteristics based on gender, age, body mass index (BMI) and occupation. According to Table 1, there were 12 male subjects (60%) and 8 female subjects (40%). With regards to the subjects' age, 9 people (45%) were in the age range of 17-24 years, 7 people (35%) were in the age range of 25-32 years, and 4 people (20%) were in the age range of 33-40 years. Data on BMI showed that of the 20 subjects, 3 were categorized as underweight (15%), 11 were categorized as normal (55%) and 6 were categorized as overweight (30%). Based on occupation, 6 people (30%) were students, 4 people (20%) worked as entrepreneurs/private employees, 2 people (10%) were civil servants, and 8 people (40%) were athletes.

To determine which statistical test to use, a normality test was first performed using the Shapiro-Wilk test. If the probability value (p-value) was greater than 0.05, the data passed the normal distribution, or in other words, the data was normally distributed. As shown in Table 2, the normality test of data distribution using the Shapiro-Wilk test obtained a probability value of p = 0.084 before the isometric quadriceps exercise and

p = 0.065 after the isometric quadriceps exercise, which means that the data were normally distributed.

The mean pain score before and after the intervention was tested using the paired sample t-test. The difference in score is considered significant if the p-value is less than 0.05. The paired sample t-test obtained a p-value of 0.000 (p<0.05), it means that there was a significant difference in pain scores before and after isometric quadriceps exercise in patients following phase I reconstruction of the ACL (Table 3).

Table 1. Subject Characteristics Based on Gender, Age, BMI dan Occupation

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	12	60
	Female	8	40
	Total	12	100
Age	17-24 years	9	45
	25-32 years	7	35
	33-40 years	4	20
	Total	20	100
Body Mass Index (BMI)	Underweight	3	15
	Normal	11	55
	Overweight	6	30
	Total	20	100
Occupation	Student	6	30
	Entrepreneur/Private Employee	4	20
	Civil Servant	2	10
	Athlete	8	40
	Total	20	100

Table 2. Normality Test Results of Pain Score Before and After Intervention

Normality test (Shapiro-Wilk test)		
VAS Score before Intervention	Mean ± SD	p
	6.00 ± 1.257	0.084
VAS Score after Intervention	3.40 ± 1.046	0.065

Table 3. Results of the Paired Sample T-Test Before and After Intervention

Paired Sample T-Test		
VAS Score before Intervention + SD	VAS Score before Intervention + SD	p
6.00 ± 1.257	3.40 ± 1.046	0.000

This study aimed to examine the effect of isometric quadriceps exercise on pain reduction after phase I reconstruction in patients with ACL injuries. The anterior cruciate ligament (ACL) is a ligament that plays an important role in regulating the rotational movement of the knee joint. An injury to the ACL will affect the movement of the knee joint, in which it will disrupt the ability of the knee joint to maintain stability during rotation, acceleration, and deceleration movements (Bliss, 2018). Many factors have been suggested to be risk factors for ACL injury, one of which is gender. The rate of non-contact ACL injuries is higher in women than in men. Several factors have been identified related to this, such as movement patterns, position, and muscle strength resulting from coordinated lower extremity activities that differ between males and females. Anatomical and hormonal factors, such as differences in ACL circumference, smaller and narrower intercondylar areas, joint weakness and the pre-ovulatory phase of the menstrual cycle in women are also risk factors for non-contact ACL injury (Sundemo et al., 2019). Lastly, neuromuscular disorders such as knee valgus position, lack of muscle control (activation of quadriceps and hamstring muscles), hip and trunk are also suggested to be involved in the etiology of this injury (Cheung et al., 2015). Neuromuscular disorders can be minimized by doing exercises (Petushek et al., 2021). Age is also considered as a risk factor for ACL injury. As people get older, they become the activities they do become more at risk, which can lead to injury compared

to when they were younger. In one study, it was found that senior athletes suffered more injuries than other age categories, but there was no significant effect between age and the incidence of injury (Harmer, 2019). ACL injuries are most common in young and active individuals, which can have a negative impact on their physical and psychological well-being in the long term (Filbay & Grindem, 2019). Knee injuries can also occur in someone with a high BMI; this is due to changes in direction and momentum that can affect knee stability (Amoako et al., 2017). ACL injuries are indeed most often experienced by athletes, particularly when landing incorrectly from a jump, where there is greater knee valgus angle (Numata et al., 2018). In addition to athletes, this injury also frequently occurs in students who like to do sports such as basketball and football.

The management of ACL injuries can be conservative or operative. One form of operative treatment is reconstruction. ACL reconstruction aims to restore the function of the knee, which is weak and unstable due to the injury. In addition, reconstruction aims to reduce the incidence of secondary injuries that can occur to the meniscal and osteochondral (Bliss, 2018). Several other factors for choosing reconstruction include age, instability of the knee joint, and the patient's desire to be able to return to sports and work. Return to sports is one of the main goals for athletes who undergo reconstruction (Grevnerts et al., 2021). Patients with ACL injuries who underwent reconstruction obtained better results than those who did not, especially in the function of the knee joint (Sonesson & Kvist, 2022). ACL reconstruction should be combined with pre-operative and post-operative rehabilitation (Bliss, 2018). Pre-operative rehabilitation should be performed to improve postoperative outcomes and should be carried out as soon as possible after the patient is diagnosed with ACL injury (Shaarani et al., 2013). Post-reconstruction rehabilitation is divided into four phases. Phase I begins after surgery and continues for 2-4 weeks after reconstruction. In this phase, one of the main goals is pain reduction. In addition, passive extension of the knee joint and quadriceps muscle strengthening should be initiated as soon as possible, on the first day after reconstruction. Active or passive motion exercises such as isometric quadriceps exercises, active straight leg raises, prone hangs and heel slides are needed in this phase (Van Melick et al., 2016). These exercises, besides aiming to reduce pain, can also reduce oedema, restore range of motion (ROM) and strengthen the quadriceps muscle (Filbay & Grindem, 2019).

Pain is experienced by everyone immediately after reconstruction. It greatly affects joint function, muscle strength, stability, and range of motion. Knee pain is usually measured using a visual analogue scale or a numerical rating scale (Bliss, 2018). Pain that occurs after phase I ACL reconstruction is associated with osteochondral damage and progressive arthrosis of the knee. Careful examination including radiological examination and blood tests are needed to identify the cause of ongoing pain. The potential for nerve injury, particularly with regard to the infrapatellar branch of the saphenous nerve, when performing a medial hamstring graft should be considered. Nerve injury after ACL reconstruction can cause chronic pain syndrome; this occurs if the reconstructed knee has undergone several other surgical interventions prior to this reconstruction (Bliss, 2018).

Isometric quadriceps exercise is a commonly prescribed exercise for patients who have undergone reconstruction of the ACL, primarily for reducing pain (Adams et al., 2012). Isometric quadriceps exercise is done by contracting the quadriceps muscle. It is an exercise that is easy for the patient to understand, safe to do and does not require any special equipment (Anwer & Alghadir, 2014). When doing this isometric exercise, there is a change in muscle morphology where the muscle mass increases, which is caused by the increasing number of mitochondria produced from this exercise. Isometric quadriceps exercise results in a constant length of muscle during contraction, where there is no joint movement but there is an increase in muscle tone that we know as static contraction. A frequent problem following ACL reconstruction is weakness in the quadriceps muscle (Hart et al., 2015). The effect of this strengthening exercise will increase dynamic muscle strength and form power that can strengthen the quadriceps muscle, thereby reducing excessive load or stress, which can ultimately reduce knee pain (Huang et al., 2018).

This study has several limitations. The main limitation is the lack of a control group, which makes it difficult to be certain that the reduced pain experienced by patients in this study was caused by the intervention of interest (isometric quadriceps exercise) and not by other variables. We did not collect supporting data from patients included in our study that were associated with their ACL reconstruction, such as the type of graft

used and previous history of injuries, which could have affected their pain results. This study also had a small sample size, which limits the generalizability of our findings.

CONCLUSION

It can be concluded that isometric quadriceps exercise can significantly reduce pain in patients after phase I ACL reconstruction at Bali Royal Hospital, Denpasar, Bali. This exercise can be one of the best interventions to be prescribed because besides being effective in reducing pain, this exercise is easy to do, does not need any special equipment and does have any side effects. Future research can examine other outcomes, such as muscle strength, as isometric quadriceps exercise also has a large impact in increasing muscle strength, which is another problem that patients experience after ACL reconstruction. Future research should be conducted with larger sample sizes and a more robust design, such as a randomized controlled trial (RCT), to further confirm the effect of isometric quadriceps exercise on pain reduction after phase I reconstruction in patients with ACL injury.

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CONFLICT OF INTEREST

All authors declare that there is no conflict of interest whatsoever in this study.

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