Enhanced knee joint function due to accelerated rehabilitation exercise after anterior cruciate ligament reconstruction surgery in Korean male high school soccer players.

Myungchun Lee
Dong Jun Sung
Joohyung Lee
Inyoung Oh
SoJung Kim
Rowan University, kims@rowan.edu

See next page for additional authors

Follow this and additional works at: https://rdw.rowan.edu/csm_facpub

Part of the Rehabilitation and Therapy Commons, and the Sports Sciences Commons

Let us know how access to this document benefits you - share your thoughts on our feedback form.

Recommended Citation
Lee, Myungchun; Sung, Dong Jun; Lee, Joohyung; Oh, Inyoung; Kim, SoJung; Kim, Seungho; and Kim, Jooyoung, "Enhanced knee joint function due to accelerated rehabilitation exercise after anterior cruciate ligament reconstruction surgery in Korean male high school soccer players." (2016). Faculty Scholarship for the College of Science & Mathematics. 184.
https://rdw.rowan.edu/csm_facpub/184

This Article is brought to you for free and open access by the College of Science & Mathematics at Rowan Digital Works. It has been accepted for inclusion in Faculty Scholarship for the College of Science & Mathematics by an authorized administrator of Rowan Digital Works. For more information, please contact brush@rowan.edu.
Enhanced knee joint function due to accelerated rehabilitation exercise after anterior cruciate ligament reconstruction surgery in Korean male high school soccer players

Myungchun Lee¹, Dong Jun Sung², Joohyung Lee³, Inyoung Oh³, Sojung Kim⁴, Seungho Kim⁵, Jooyoung Kim³,*

¹Graduate School of Education, Dankook University, Yongin, Korea
²Division of Sport Science, Konkuk University, Choongju, Korea
³College of Physical Education, Kookmin University, Seoul, Korea
⁴Sports Industry Research Center, Korea National University of Transportation, Choongju, Korea
⁵Department of Football Management, MunKyung College, Mungyeong, Korea

This study was conducted on Korean male high school soccer players who underwent anterior cruciate ligament reconstruction (ACLR) to identify the effects of an accelerated rehabilitation exercise (ARE) program on knee joint isometric strength, thigh circumference, Lysholm score, and active balance agility. We assigned eight test participants each to a physical therapy group (PTG) and an accelerated rehabilitation exercise group (AREG), and compared differences between the groups. Both the PTG and AREG showed significant increases in 30° away and 60° toward isometric strength after treatment. In addition, significant differences were observed in these strength tests between the two groups. Both groups also showed significant increases in thigh circumference, Lysholm score, and active balance agility after treatment, but no significant differences were observed between the two groups. We conclude that the ARE treatment was more effective for improving isometric strength of the knee joint than that of physical therapy, and that an active rehabilitation exercise program after ACLR had positive effects on recovery performance of patients with an ACL injury and their return to the playing field.

Keywords: Accelerated rehabilitation exercise, Anterior cruciate ligament reconstruction, Physical therapy, Soccer players

INTRODUCTION

Soccer is one of the most popular sports worldwide and more than 200 million professional and amateur soccer players enjoy the sport (Dvorak et al., 2004). Soccer is a sport that anyone can easily participate and have fun while enjoying the benefits of exercise (Lee, 1994). However, competitive soccer involves medium and high intensity contact and collisions, including player-to-player, player-to-ground, player-to-ball, and player-to-goalpost collisions. Most soccer injuries occur to the lower extremities. Ankle injuries account for 16%–29% of all injuries (Junge et al., 2002; Kakavelakis et al., 2003), whereas 7%–36% are knee injuries (Kakavelakis et al., 2003; Söderman et al., 2001). These findings reveal that knee injuries occur predominantly in soccer and injuries of the anterior cruciate ligament (ACL) are the most common in soccer as well as in other sports (Moses et al., 2012). Soccer inherently involves a higher risk of ACL injury than other sports (Alen-torn-Geli et al., 2009).

The ACL is one of the four major ligaments that minimize stress on the knee joint and ensures joint stability (Stojanovic and Ostojic, 2012) through resistance against motion caused by anterior tibial translation and internal tibial rotation. ACL injuries of
ten occur due to excessive internal rotation of the femur on the tibia. Although all injuries have a negative impact on player performance, an ACL injury leads to disuse atrophy of the thigh muscles (Takarada et al., 2000), which can reduce hip muscle strength (Elmqvist et al., 1989), and negatively affect performance and recovery time of soccer players. In addition, an ACL injury destabilizes the knee joint, reduces control of nerve roots (Trulsson et al., 2010), decreases active range of motion (ROM) of the joint and increases the possibility of fibrosis and other physical injuries and disabilities (Papandreou et al., 2009). Therefore, a proper rehabilitation program is needed to prevent such secondary dysfunction and disabilities. Conservative treatment is typically used for patients with mild ACL injuries, whereas anterior cruciate ligament reconstruction (ACLR) is performed on those with a severe ACL injury.

Use of a minimally invasive ACLR procedure has enabled quick recovery after surgery, resulting in earlier joint mobility and weight-bearing ability. It has also contributed to increased recovery of performance when combined with an early rehabilitation program immediately after surgery (Cho and Park, 1999). One of the major objectives after ACLR is to recover normal thigh muscle strength (Augustsson et al., 2006) by improving muscle strength and dynamic exercise ability. Thus, various rehabilitation exercise programs can be applied after ACLR. Among them, an accelerated rehabilitation exercise (ARE) program contributes to speed recovery of muscles and prevent complications, including fibrosis of the joint (Wilk et al., 2003). In addition, ARE reduces pain in the knee joint by enabling early weight bearing (Tyler et al., 1998) and can help injured players return to the playing field sooner (Beynnon et al., 2005; Shelbourne and Nitz, 1990). Therefore, we targeted male high school soccer players who underwent ACLR to identify the possible effects of ARE on isometric strength, Lysholm score, and active balance agility. We hypothesized that an ARE program would improve knee joint function in participants who underwent ACLR.

**MATERIALS AND METHODS**

**Subjects**

This study was conducted with 16 male high school soccer players who had previously undergone ACLR. The test subjects were diagnosed with a complete ACL rupture, had received an autograft or allograft, and did not have any particular complications or an inflammatory reaction. The test subjects were well informed of the study contents before initiating the rehabilitation or physical therapy program (Ediz et al., 2012; Zalta, 2008) and voluntarily consented to participate.

The participants were divided into an ARE group, who participated in the rehabilitation program (AREG, n = 8) and a physical therapy group (PTG) group, who did not participate in the rehabilitation program (PTG, n = 8, control). Their physical characteristics are listed in Table 1.

**ARE program**

The ARE program suggested by Shelbourne and Nitz (1990) was modified and applied as a rehabilitation exercise program carried out in four phases, depending on the presence or absence of pain and the level of muscle improvement of the test subjects. The ARE program started 2 days after surgery and was performed for 2 hr per session, 5 times per week. The objectives of each phase of the ARE program were: Phase 1 was used to relieve inflammation and edema; phase 2 was used to increase ROM; phase 3 was used to boost muscle strength; and phase 4 was used to improve balance ability.

Exercise intensity during each phase was determined after considering the patient’s pain level and compliance with the rehabilitation program. The outline of the ARE program is shown in Table 2.

**Lower extremity muscle test**

The lower extremity muscle test was performed using the Biodex III (Biodex Medical Systems, Shirley, NY, USA). The subjects sat in the Biodex chair with the hip joint at 90° and the motion axis of the knee joint straight with that of the machine. The trunk, hip, and thigh were fixed with waist and thigh belts. The medial ankle, its straight upper bone, and a lever were strapped with a belt. The test angles were limited to 0°–90° to prevent any injury during the test. A pre-exercise was done as practice once before the test was conducted.

To test muscle function of the knee joint, maximum away and toward isometric strength of the subjects were measured for 5 sec at knee joint flexion of 30° and 60°, with a 1-min rest between the tests at each angle.

**Measurement of femoral circumference**

Femoral circumference was measured using the method sug-
gested by McRae and Esser (2008). After the test subject extended their leg, a point 18 cm from the joint line was marked, and the circumference was measured with a tape.

### Dynamic balance ability test

Dynamic balance ability was measured using the Balance System SD (Biodex Medical Systems). When a moving cursor at the center of a circle displayed on the screen leaned to one side, the subject balanced to maintain the most stable position possible without taking their feet off a footplate. The balance index shows ability to control the unstable circular footplate, which was divided into A, B, C, and D ranges as it moved away from the center of the circle to the perimeter and was sectioned I, II, III, and IV along the X and Y axes. The circular footplate had a 5° incline interval for each range, and the total incline from the stable position to range D was 20°. The A-I, A-II, A-III, A-IV, B-I, B-II, B-III, B-IV, C-I, C-II, C-III, C-IV, D-I, D-II, D-III, and D-IV values were displayed in the pre-/poststate with the inner/outer balance distributions. The overall indices, pre-/postindices, and inner/out- er indices were calculated with a computer.

### Lysholm score (knee joint function index)

The knee joint function index was assessed with Lysholm’s (Lysholm and Gillquist, 1982) scoring criteria. The knee joint func-

---

**Table 2. Accelerated rehabilitation exercise programs**

| Phase | Rehabilitation contents | Load/set |
|-------|--------------------------|----------|
| Phase 1 (1–2 weeks) | Continuous passive motion | 30 min |
| Goal: edema and inflammation control | Ankle pumps with Theraband | 30 times × 3 sets |
| | Quadriceps setting | 10-sec maintenance, 20 times × 3 sets |
| | Straight leg raise with brace | 10-sec maintenance, 10 times × 3 sets |
| | Upper-body ergometer | 15 min |
| | Cryotherapy | 15 min |
| | Brace/two crutches | - |
| Phase 2 (2–4 weeks) | Wall slide | 20 times × 3 sets |
| Goal: expansion of range of motion | Straight leg raise (4 ways) with cuff | 10-sec maintenance, 20 times × 3 sets |
| | Patellar mobilization | - |
| | Quadriceps setting | 10-sec maintenance, 20 times × 3 sets |
| | Passive knee extension | 10-sec maintenance, 20 times × 3 sets |
| | Mini squat | 10-sec maintenance, 20 times × 3 sets |
| | Heel raise | 10-sec maintenance, 20 times × 3 sets |
| | Weight shift (lateral/front/back step) with Theraband – partial weight bearing | 30 times × 3 sets |
| | Box step up (15 cm) – front/lateral | 30 times × 3 sets |
| | Knee extension (standing) with cuff | 30 times × 3 sets |
| | Mini trampoline/baps board | 30 times × 3 sets |
| | Bicycle | 15 min |
| | Cryotherapy | 15 min |
| | Brace/crutches | - |
| Phase 3 (4–9 weeks) | Straight leg raise (4 ways) with cuff | 10-sec maintenance, 20 times × 3 sets |
| Goal: enhancement of strength | Box step up (30 cm) – front/lateral | 30 times × 3 sets |
| | Mini trampoline/baps board | 1 min × 3 sets |
| | Leg press/extension/curl (machine) | 20 times × 3 sets (isometric exercise) |
| | Bicycle | 15 min |
| | Gymball squat | 10-sec maintenance, 20 times × 3 sets |
| | Lunge | 20 times × 3 sets |
| | Treadmill walk (incline 15 degrees, speed 3.1 mile/hr, 4 ways) | Each way 10 min |
| | Stair stepper | 10 min |
| | Cryotherapy | 15 min |
| | Brace | - |
| Phase 4 (8–12 week) | Straight leg raise (4 ways) with cuff | 10-sec maintenance, 20 times × 3 sets |
| Goal: improvement of balance agility | Box step up (60 cm) – front/lateral | 30 times × 3 sets |
| | Mini trampoline/baps board | 1 min × 3 sets (closed eyes) |
| | Bicycle | 15 min |
| | Leg press/extension/curl (machine) | 20 times × 3 sets (isometric exercise) |
| | Gymball squat | 10-sec maintenance, 20 times × 3 sets |
| | Treadmill walk (incline 20 degrees, speed 3.1 mile/hr, 4 ways) | Each way 10 min |
| | Stair stepper | 15 min |
| | Cryotherapy | 15 min |
| | Brace | - |
tion index (or Lysholm index) has a 0–100 point scale, which consists of limp, support, stair-climbing, squatting, instability during walking, running and jumping, pain, swelling, and thigh hypotrophy categories.

**Statistical analysis**

Descriptive data are presented as mean±standard error. A 2 (group: PTG vs AREG) × 2 (time: before and after 12 weeks) repeated-measures analysis of variance for the training and treatment programs was used to assess differences between the conditions. Paired and independent t-tests were carried out to detect differences. A $P<0.05$ was considered significant. All analyses were performed using IBM SPSS Statistics ver. 20.0 (IBM Co., Armonk, NY, USA).

**RESULTS**

**Changes in knee joint isometric force in the PTG and AREG**

The $30^\circ$ away knee joint isometric force increased significantly in the PTG from $162.27\%\pm7.08\%$ before treatment to $194.16\%\pm8.07\%$ after treatment ($P=0.013$). The $30^\circ$ away knee joint isometric force also increased significantly in the AREG from $143.06\%\pm13.54\%$ to $236.51\%\pm9.7\%$. A significant group×time interaction was also observed ($P<0.001$), and a significant difference in the posttreatment $30^\circ$ away isometric force was observed between the PTG and the AREG ($P=0.03$).

The $60^\circ$ toward isometric strength in the PTG increased significantly from $212.83\%\pm17.43\%$ before treatment to $274.3\%\pm19.04\%$ after treatment ($P=0.01$), and that of the AREG increased from

---

**Fig. 1.** Effects of 12-week physical therapy (PT) and accelerated rehabilitation exercise (ARE) programs on isometric strength of the knee joint. (A) $30^\circ$ away and toward in the PT and ARE groups, (B) $60^\circ$ away and toward in the PT and ARE groups. *Significantly different between pre- and posttreatment at $P<0.05$. **Significantly different between pre- and posttreatment at $P<0.01$. ***Significantly different between pre- and posttreatment at $P<0.001$. ††Significantly different between PT group (PTG) and ARE group (AREG) in posttreatment, at $P<0.05$ and $P<0.01$, respectively. Pre, pretreatment; Post, posttreatment; BW, body weight.

**Fig. 2.** Effects of a 12-week physical therapy or accelerated rehabilitation exercise program on thigh circumference and Lysholm score. ★Significantly different between pre- and posttreatment at $P<0.01$. Pre, pretreatment; Post, posttreatment; PTG, physical therapy group; AREG, accelerated rehabilitation exercise group.
In this study, we applied either a PT or an ARE program to Korean male high school soccer players who underwent ACLR and examined the effects of both programs on isometric strength, Lysholm score, balance, and thigh circumference. The main finding was that 12 weeks of ARE and PT both had positive impacts on all measured parameters. Notably, the results suggest that ARE could be more effective for improving 30° away and 60° toward isometric strength than those of PT.

**Effects of PT and ARE on knee joint isometric strength**

Knee joint muscle strength after ACLR tends to decrease on the affected side compared to that on the normal side (Gerber et al., 2009). Edema is likely to occur in knee joints after surgery, which could suppress quadriceps contraction. Prolonged edema can also cause shrinkage of the quadriceps due to the inhibited neuromuscular condition. Previous studies have suggested that 60 mL of edematous fluid can reduce contraction of the quadriceps by up to 50% (Spencer and Hayes, 1984).

Only passive rehabilitation therapies were used in the 1980s, which allowed only 30°–60° of knee joint flexion and banned weight bearing for the first 6 weeks to protect transplanted tissues after ACLR. Later, many studies reported that early passive joint exercise did not impair transplanted muscle tissues, which was later clinically proven (Demiao et al., 1992; Shelbourne and Nitz, 1990). Thus, transplanted muscle tissues were found to play a role as an ACL in the absence of necrotized tissues within 3 weeks after surgery and that an adequate amount of stress to fibroblasts is necessary to facilitate growth of collagenous fibers in transplanted tissues (Hannafin et al., 1995; Rougraff et al., 1993). Isometric exercise is widely used as a rehabilitation exercise for muscle loss and atrophy due to limited movement (Wei, 2000). Therefore, isometric exercise is widely used in the early stages of rehabilitation to strengthen the muscles around the knee joint. Isometric exercise, which improves muscle strength using the motion range available depending on the angle of an early unstable joint, is a treatment or rehabilitation exercise that is highly stable and provides adequate exercise load to improve muscle strength in patients with exercise injuries using all ROMs (Osternig, 1986). The muscle strength test is mainly used to evaluate recovery after ACLR or to evaluate the effects of a exercise program (Ageberg et al., 2009).

In this study, both the PT and ARE programs had positive effects on away and toward isometric strength. Karasel et al. (2010) showed a significant difference in knee extensor strength at a 60°/
sec angular velocity after applying ARE, whereas Konishi et al. (2012) reported improved extensor muscle strength after closed kinetic channel exercise. Similarly, rehabilitation exercise after ACLR is effective for improving extensor function. We also showed improved away (extension) isometric strength after ARE and PT, indicating that rehabilitation exercise after ACLR could positively affect the extensors. However, the significant change in toward (flexor) isometric tension that we observed was not consistent with results of previous studies. Karasel et al. (2010) reported no differences in flexor muscle strength after ARE, whereas Jang et al. (2011) observed significant changes in extensors but not flexors. This could be ascribed to the compensation mechanism between extensors and flexors, by weakened muscle function, or muscular atrophy of the extensor after ACL injury. In addition, previous studies also observed isokinetic functions, but further studies are needed to assess differences between measurement parameters, but we only evaluated isometric strength within a limited angular range in early-stage injuries.

The PTG and AREG showed significant differences in 30° away and 60° toward isometric strength, indicating that participating in a dynamic rehabilitation program is more suitable for recovering function after ACLR. The results also show that the ARE program was more effective for improving isometric strength of the thigh muscles and knee joint. In addition, because the ability or inability of patients to return to high-intensity sports activities is an indicator to determine the success of ACLR treatment (Kvist, 2004), the ARE applied here could be successful used a rehabilitation exercise program for patients with a limited ROM.

Effects of PT and ARE on thigh circumference and Lysholm score.

Thigh muscle atrophy is the most common symptom after knee joint injury due to immobilization after use of a brace. Gerber et al. (1985) reported a 10% decrease in thigh circumference at the quadriceps and a 4% decrease in that of the hamstrings in patients with chronic ACL injuries. Reat and Lintner (1997) also reported that thigh circumference of the affected side decreased 10.8% compared to that of the normal side after ACLR. Itoh et al. (1992) reported that the quadriceps and hamstring can atrophy or weaken substantially if left untreated after an ACL injury. Arangio et al. (1997) reported that thigh circumference of the affected side that underwent ACLR decreased by 1.8% compared to that of the normal side and that quadriceps area measured by magnetic resonance imaging indicated an 8.6% decrease. As such, an ACL injury reduces thigh circumference and weakens the quadriceps. We observed that thigh circumference increased in both groups, indicating the effectiveness of the programs to prevent muscular atrophy after ACLR. Thigh circumference in the PTG increased by 3.06%, from 47.22±0.58 to 48.73±0.64 cm, whereas that in the AREG increased 5.01% from 46.36±0.65 to 48.87±0.84 cm. This tendency for improvement suggests that a more effective rehabilitation program could be developed if the duration and contents of the program were properly modified before application.

The widely used knee joint function evaluation scales include the Kujala score, the Lysholm score, the Cincinnati knee rating system, and the patellofemoral joint evaluation scale. These methods measure discomfort, pain, and edema. Among them, the Lysholm score consists of items, including limping life, level of support, such as use of braces, stair-climbing, squatting, instability during walking, running, and jumping, pain, swelling, and thigh hypertrophy, and has a 100-point scale (Lysholm and Gillquist, 1982). A score of 95–100 is considered as “excellent,” 84–94, “good,” 65–83, “normal,” and <64, “poor.” This test is widely used in clinical practice and knee joint-related studies (Lysholm and Gillquist, 1982).

Novak et al. (1996) reported that 19 patients who underwent knee arthroscopic surgery for ACLR after ACL injury had average Lysholm scores of 95 points 2 yr after the surgery. Natri et al. (1996) conducted a follow-up observation of 90 patients who underwent ACLR procedure after ACL injury and reported that 76% had Lysholm scores >82 points 3.5 yr after the surgery. In this study, the PTG and the AREG showed significant increases after treatment, although no differences were detected between the groups. The AREG showed a 54% improvement, supporting the argument that more active muscle strengthening exercises during the early stage of rehabilitation is more effective for recovering of muscle and joint functions. An active rehabilitation exercise and treatment program can shorten the recovery time for injured athletes, and accelerate their return to the field (Natri et al., 1996; Novak et al., 1996).

Effects of PT and ARE on active balance ability

The balance sense of the knee joint is maintained by proprioception from mechanical receptors in ligaments and several other structures to sustain the body balance control mechanism. Shirai-shii et al. (1996) conducted a balance test on test subjects by dividing them into an ACLR group, a non-ACLR group, and a normal control group, and reported that the ACLR group showed a lower level of balance ability than that of the normal control
group, but a higher level than that of the non-ACLR group. In addition, Mattacola et al. (2002) reported almost no difference on a balance ability test compared to that of the normal control group 18 months after ACLR. Harrison et al. (1994) reported no difference between the ACLR and non-ACLR control group in terms of postural balance control.

Soccer players must have an excellent sense of balance of the foot to control the ball, which is required when they land on the ground after jumping to head the ball. If their balance ability is poor, they are more likely to suffer a sprain or contusion of a knee ligament, so good balance is an important physical requirement for soccer players. Therefore, the balance abilities of soccer players are remarkably better than their ordinary counterparts (Park et al., 2009). We conducted a dynamic balance ability test using a moving ground to evaluate balance control ability of the soccer players. The PTG and AREG showed significant changes between before and after treatments, but no differences between the two groups were observed. The PTG showed only a 41.4% improvement, the AREG presented a 52.1% increase in balance ability, indicating the potential benefits of the ARE.

After applying PT or ARE programs to two groups of male high school soccer players who underwent ACLR procedures after ACL injury, both treatments had positive effects on isometric strength, thigh circumference, Lysolm score, and active balance ability of knee joints. We found that the ARE was particularly more effective for improving 30° away and 60° toward isometric strength. Although no differences were observed between the other parameters, the differences in isometric strength contribute to preventing muscle loss and accelerate recovery from injury. This means that an ARE program is essential for helping injured patients return to the playing field and everyday life and that the benefits of various rehabilitation exercise programs need to be compared and verified to develop a more effective rehabilitation program in the future.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

Ageberg E, Roos HP, Silbernagel KG, Thomeé R, Roos EM. Knee extension and flexion muscle power after anterior cruciate ligament reconstruction with patellar tendon graft or hamstring tendons graft: a cross-sectional comparison 3 years post surgery. Knee Surg Sports Traumatol Arthrosc 2009;17:162-169.

Alentorn-Geli E, Myer GD, Silvers HJ, Samitier G, Romero D, Lázaro-Haro C, Cugat R. Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 2: a review of prevention programs aimed to modify risk factors and to reduce injury rates. Knee Surg Sports Traumatol Arthrosc 2009;17:859-879.

Arangio GA, Chen C, Kalady M, Reed JF 3rd. Thigh muscle size and strength after anterior cruciate ligament reconstruction and rehabilitation. J Orthop Sports Phys Ther 1997;26:238-243.

Augustsson J, Thomeé R, Lindén C, Folkesson M, Tranberg R, Karlsson J. Single-leg hop testing following fatiguing exercise: reliability and biomechanical analysis. Scand J Med Sci Sports 2006;16:111-120.

Beynon B, Uh BS, Johnson RJ, Abate JA, Nichols CE, Fleming BC, Poole AR, Roos H. Rehabilitation after anterior cruciate ligament reconstruction: a prospective, randomized, double-blind comparison of programs administered over 2 different time intervals. Am J Sports Med 2005;33:347-359.

Cho JH, Park WH. Characteristic analysis of knee joint isokinetic parameters after anterior cruciate ligament reconstruction. Korean J Sports Med 1999;17:176-187.

DeMaio M, Noyes FR, Mangine RE. Principles for aggressive rehabilitation after reconstruction of the anterior cruciate ligament. Orthopedics 1992;15:385-392.

Dvorak J, Junge A, Graf-Baumann T, Peterson L. Football is the most popular sport worldwide. Am J Sports Med 2004;32(1 Suppl):3S-4S.

Ediz L, Ceylan MF, Turktas U, Yarunis I, Hiz O. A randomized controlled trial of electrostimulation effects on effusion, swelling and pain recovery after anterior cruciate ligament reconstruction: a pilot study. Clin Rehabil 2012;26:413-422.

Elmqvist LG, Lorentzon R, Johansson C, Längström M, Fagerlund M, Fugl-Meyer AR. Knee extensor muscle function before and after reconstruction of anterior cruciate ligament tear. Scand J Rehabil Med 1989;21:131-139.

Gerber C, Hoppeler H, Claassen H, Robotti G, Zehnder R, Jakob RP. The lower-extremity musculature in chronic symptomatic instability of the anterior cruciate ligament. J Bone Joint Surg Am 1985;67:1034-1043.

Gerber JP, Marcus RL, Dibble LE, Greis PE, Burks RT, LaStayo PC. Effects of early progressive eccentric exercise on muscle size and function after anterior cruciate ligament reconstruction: a 1-year follow-up study of a randomized clinical trial. Phys Ther 2009;89:51-59.

Hannafin JA, Arnoczky SP, Hoonjan A, Torzilli PA. Effect of stress deprivation and cyclic tensile loading on the material and morphologic properties of canine flexor digitorum profundus tendon: an in vitro
study. J Orthop Res 1995;13:907-914.
Harrison EL, Duenkel N, Dunlop R, Russell G. Evaluation of single-leg standing following anterior cruciate ligament surgery and rehabilitation. Phys Ther 1994;74:245-252.
Itoh H, Ichihashi N, Maruyama T, Kurosaka M, Hirohata K. Weakness of thigh muscles in individuals sustaining anterior cruciate ligament injury. Kobe J Med Sci 1992;38:93-107.
Jang JW, Kim SS, Kim TS. Effect of 16 weeks functional rehabilitation exercise on knee function recovery in women's soccer player after anterior cruciate ligament reconstruction. J Sport Leis Stud 2011;45:863-876.
Junge A, Rüsch D, Peterson L, Graf-Baumann T, Dvorak J. Prevention of soccer injuries: a prospective intervention study in youth amateur players. Am J Sports Med 2002;30:652-659.
Kakavelakis KN, Vlazakis S, Vlahakis I, Charissis G. Soccer injuries in childhood. Scand J Med Sci Sports 2003;13:175-178.
Karasek S, Akpinar B, Gülbahar S, Baydar M, El O, Pinar H, Tatari H, Karaoğlan O, Akalin E. Clinical and functional outcomes and proprioception after a modified accelerated rehabilitation program following anterior cruciate ligament reconstruction with patellar tendon autograft. Acta Orthop Traumatol Turc 2010;44:220-228.
Konishi Y, Oda T, Tsukazaki S, Kinugasa R, Fukubayashi T. Relationship between quadriceps femoris muscle volume and muscle torque at least 18 months after anterior cruciate ligament reconstruction. Scand J Med Sci Sports 2012;22:791-796.
Kvist J. Rehabilitation following anterior cruciate ligament injury: current recommendations for sports participation. Sports Med 2004;34:269-80.
Lee YS. Prevention program for soccer injuries. Korean J Sports Med 1994;12:43-53.
Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. Am J Sports Med 1982;10:150-154.
Mattacola CG, Perrin DH, Gansneder BM, Gieck JH, Saliba EN, McCue FC 3rd. Strength, functional outcome, and postural stability after anterior cruciate ligament reconstruction. J Athl Train 2002;37:262-268.
McRae R, Esser M. Practical fracture treatment. 5th ed. Philadelphia: Churchill Livingstone; 2008.
Moses B, Orchard J, Orchard J. Systematic review: annual incidence of ACL injury and surgery in various populations. Res Sports Med 2012;20:157-179.
Natri A, Järvinen M, Kannus P. Primary repair plus intra-articular iliotibial band augmentation in the treatment of an acute anterior cruciate ligament rupture. A follow-up study of 70 patients. Arch Orthop Trauma Surg 1996;115:22-27.
Novak Pj, Bach BR Jr, Hager CA. Clinical and functional outcome of anterior cruciate ligament reconstruction in the recreational athlete over the age of 35. Am J Knee Surg 1996;9:111-116.
Osternig LR. Isokinetic dynamometry: implications for muscle testing and rehabilitation. Exerc Sport Sci Rev 1986;14:45-80.
Papandreou MG, Billis EV, Antonogiannakis EM, Papaioannou NA. Effect of cross exercise on quadriceps acceleration reaction time and subjective scores (Lysholm questionnaire) following anterior cruciate ligament reconstruction. J Orthop Surg Res 2009;4:2.
Park EK, Chung JW, Jin YS, Chung JS. Association of skill-related fitness with dynamic balance, isokinetic knee strength, and anaerobic power in youth elite soccer player. Korean J Phys Educ 2009;48:577-584.
Reat JF, Lintner DM. One-versus two-incision ACL reconstruction. A prospective, randomized study. Am J Knee Surg 1997;10:198-208.
Rouglafl B, Shelbourne KD, Gerth PK, Warner J. Arthroscopic and histologic analysis of human patellar tendon autografts used for anterior cruciate ligament reconstruction. Am J Sports Med 1993;21:277-284.
Shelbourne KD, Nitz P.Accelerated rehabilitation after anterior cruciate ligament reconstruction. Am J Sports Med 1990;18:292-299.
Shiraishi M, Mizuta H, Kubota K, Otsuka Y, Nagamoto N, Takagi K. Stabilometric assessment in the anterior cruciate ligament-reconstructed knee. Clin J Sport Med 1996;6:32-39.
Söderman K, Adolphson J, Lorentzon R, Alfredson H. Injuries in adolescent female players in European football: a prospective study over one outdoor soccer season. Scand J Med Sci Sports 2001;11:299-304.
Spencer JD, Hayes KC, Alexander II. Knee joint effusion and quadriceps reflex inhibition in man. Arch Phys Med Rehabil 1984;65:171-177.
Stojanovic MD, Ostojic SM. Preventing ACL injuries in team-sport athletes: a systematic review of training interventions. Res Sports Med 2012;20:223-238.
Takarakya, Takazawa H, Ishii N. Applications of vascular occlusion diminish disuse atrophy of knee extensor muscles. Med Sci Sports Exerc 2000;32:2035-2039.
Trulsson A, Roos EM, Ageberg E, Garwicz M. Relationships between postural orientation and self reported function, hop performance and muscle power in subjects with anterior cruciate ligament injury. BMC Musculoskelet Disord 2010;11:143.
Tyler TF, McHugh MP, Gleim GW, Nicholas SJ. The effect of immediate weightbearing after anterior cruciate ligament reconstruction. Clin Orthop Relat Res 1998;357:141-148.
Wei SH. Dynamic joint and muscle forces during knee isokinetic exercise. Proc Natl Sci Counc Repub China B 2000;24:161-168.
Wilk KE, Reinold MM, Hooks TR. Recent advances in the rehabilitation of isolated and combined anterior cruciate ligament injuries. Orthop Clin North Am 2003;34:107-137.
Zalta J. Massage therapy protocol for post-anterior cruciate ligament reconstruction patellofemoral pain syndrome: a case report. Int J Ther Massage Bodywork 2008;1:11-21.