２回目の膝前十字靭帯再建術を経験した女子バスケットボール選手における大腿四頭筋とハムストリングス筋力の特徴：症例報告

Characteristics of the Quadriceps and Hamstring Strength of a Female Basketball Player Sustained after Secondary Anterior Cruciate Ligament Reconstruction: A Case Report

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ABSTRACT

Background and Purpose: Most athletes return to sports 9 to 12 months after anterior cruciate ligament reconstruction (ACLR). While some athletes successfully return to their previous level of sports performance, some others sustain a secondary injury after returning to sports. The purpose of this case report is to review the progress of athletic rehabilitation until returning to sports, in a female basketball player who underwent a secondary ACLR after a contralateral ACLR.

Case Description: A 20-year-old female basketball player had a right ACLR with a hamstring autograft 2 years earlier. At presentation, she had a secondary ACL injury, which occurred when she planted her left foot on the floor to stop rapidly while stepping during a 2-on-2 in basketball training. The secondary ACLR was performed using an ipsilateral semitendinosus and gracilis autograft. Her goal was to participate in the All-Japan Intercollegiate Basketball Championship, without concern for her knee. At 3 months after surgery, she was allowed to start the running program. Then, athletic rehabilitation exercises such as jumping, stepping, and agility; and plyometric exercises were gradually increased in complexity, frequency, and intensity. She completely returned to basketball competition 9 months after ACLR.

Outcomes: Isokinetic strength testing was performed as an objective parameter for return

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to sports after ACLR. The data indicated that the patient’s hamstring strength was weak and hamstring-to-quadriceps strength ratios were <0.6.

Discussion: The causes of the secondary ACL rupture remain unclear. From the results of the functional performance and isokinetic knee strength tests, a third ACL rupture may be possible. Therefore, to prevent reinjury, strengthening both hamstring muscles, enhancing the raid muscle contraction of the quadriceps and hamstring, and improving neuromuscular control may be necessary.

要　約

背景と目的：多くの競技者は膝前十字靭帯再建術（ACLR）後９～12ヶ月で競技復帰する。受傷前と同じレベルで競技復帰が成功する者もいる一方で，競技復帰後に不幸にも再受傷する者もいる。本症例報告の目的は，反対側のACLRに続いて２回目のACLRを経験した女子バスケットボール選手における競技復帰までのアスレティックリハビリテーションの過程を再考することである。

症例情報：20歳女子バスケットボール選手は２年前，18歳の時，ハムストリングスの自家腱を採取した右ACLRを経験した。今回の受傷は２回目のACL損傷であり，2on2の練習中ステップ動作で急激にストップ動作をしようと左足を接地した瞬間に発生した。２回目のACLRもまた同側の半腱様筋と薄筋の自家腱を用いたSTG法で施術された。症例の目標は，膝を気にせず全日本大学バスケットボール選手権に出場することであった。術後３ヶ月の時点で，ランニングが許可され，ジャンプ，ステップ，アジリティ，プライオメトリクスエクササイズのようなアスレティックリハビリテーションは，難易度，反復回数，強度に関して徐々に展開された。選手はACLR後９ヶ月でバスケットボール競技に完全復帰した。

アウトカム：等速性筋力測定がACLR後の競技復帰における客観的指標の一つとして行われた。これらのデータでは，ハムストリングスの筋力低下やHQ比が0.6未満であったことが示された。

考察：２回目のACL断裂の原因は不明である。機能的なパフォーマンスや等速性膝筋力測定の結果から，３回目のACL断裂の可能性を否定できない。そこで，再受傷予防のために，両側のハムストリングスの筋力強化，大腿四頭筋とハムストリングスの急速な筋収縮能力の向上，そして神経筋制御能力の改善が必要である。

INTRODUCTION

Anterior cruciate ligament (ACL) tear is a devastating injury that occurs with high frequency among individuals who participate in cutting and pivoting sports such as basketball and soccer[1]. Female athletes have 3 to 8 times higher incidence of ACL injuries than their male counterparts[6,14]. For most athletes with ACL injuries, ACL reconstruction (ACLR) is chosen to allow them to return to their preinjury level of sports participation.

Generally, patients return to sports at 9 to 12 months after ACLR. Unfortunately, in a systematic review and meta-analysis, 7% of athletes who had had an ACLR had an ipsilateral reinjury and a contralateral injury rate of 8%[15].

The subject of this study was a female basketball player who returned to sports competition 9 months after undergoing a primary ACLR according to traditional guidelines and played competitive sports at her preinjury performance level. However, she unfortunately sustained a contralateral ACL injury 12 months after returning to sports following the primary ACLR. Did the secondary ACL injury occur in female basketball player as an inevitable result of ACLR? Therefore, the purpose of this case report is to review the progress of the athletic rehabilitation until returning to sport of a female basketball player who had a secondary ACLR after incurring a contralateral ACLR.

CASE DESCRIPTION

Subject History

A 20-year-old female basketball player (height, 172 cm; mass, 67 kg; body mass index, 22.6 kg/m^2) had a right ACLR with a hamstring (semitendinosus-gracilis [STG]) autograft 2 years prior, at 18 years old. In addition, she had multiple histories of ankle sprains on both feet. Her medical history was unremarkable other than the aforementioned.

The injury mechanism of the secondary ACL injury was as follows: She was injured when she planted her left foot on the floor to stop rapidly while stepping during a 2-on-2 in basketball training. The injury was non-contact in knee varus position, so-called knee-out, with the knee slightly flexed. Unfortunately, it was a secondary ACL injury. The left and right ACLRs were performed approximately 1 month and 13 months after the injury. The secondary ACLR was also performed using an ipsilateral STG autograft. The medical and lateral menisci were intact.

Clinical Impression and Isokinetic Knee Strength Testing

Her goal was to participate in the All-Japan Intercollegiate Basketball Championship, without concern for her knee, and to prevent reinjury on both knees. Her postoperative course had been uneventful without any medical problems until 3 months after surgery, and she had no difficulty in her activities of daily living. As she had a steady recovery after surgery, a running program was allowed at 3 months after surgery as planned. She continued to progress, building up strength in her hamstring, quadriceps, and gluteal muscles.

Postural screening was performed to identify alignment abnormalities that may place her at higher risk of injury. At 3 to 6 months after the surgery, she performed dynamic postural control during single-leg exercises such as single-leg squats and deadlifting at slow speed. As the movement speed increased, she performed a single-leg squat on the left and right legs without femoral adduction and internal rotation, and the depth of her single-leg squat was limited on both legs. She had poor use of hip and ankle strategies to maintain balance on a single-leg stance. Therefore, verbal and manual feedbacks were used to help her regain proper movement patterns. Then, low-level plyometric exercises were introduced and gradually progressed in complexity, frequency, and intensity.

In the late phase of the athletic rehabilitation, the plan focused on improving the strength of the hamstring and posterolateral hip musculature, and the landing and cutting techniques by reducing dynamic lower extremity valgus collapse. She fully returned to basketball competition 9 months after the ACLR.

Outcomes

Isokinetic strength testing is an objective parameter for return to sports after ACLR. Knee extensor and flexor concentric strengths were tested using the Biodex System 3 at 60°/s, 180°/s, and 300°/s through the knee range of motion from 100° flexion through full knee extension. The subject was seated in the dynamometer, with her trunk fully supported and hips flexed to 85°. The knee joint was aligned with the dynamometer axis, and the dynamometer resistance arm was secured to the distal shank. The trunk, pelvis and thigh were stabilized with straps. Following 3 to 5 practice trials, the subject performed 5 maximum effort repetitions of knee extension and flexion at 60°/s, 180°/s, and 300°/s, respectively. We monitored her peak torque-to-body weight (PT/BW) and hamstring-to-quadriceps strength (H/Q) ratios.

The PT/BW ratios for the right and left limbs were used for further analysis and calculation of the limb symmetry index (LSI) for isokinetic strength (LSI = [right score/left score] × 100%). The LSI is the frequently reported criterion to quantify function.

Figures 1 to 3 show the PT/BW in knee extension measured 9 months after the primary ACLR and 8 months after the ACLR at 60°/sec, 180°/sec, and 300°/sec, respectively. In the initial return to sports (RTS), the knee extension strength of the involved limb was lower than that of the uninvolved limb, where the left knee was not injured. In the secondary RTS, the left knee extension strength was higher than that in the initial RTS.

The PT/BW ratios in knee flexion are presented in Figures 4 to 6. Although the right knee flexion strength of the involved

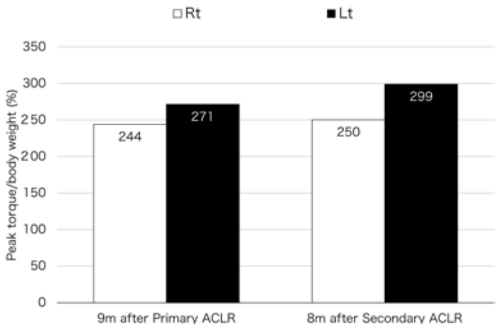

Figure 1: Peak torque-to-body weight ratio at 60°/s (Nm) in extension, measured 9 months after the primary ACLR and 8 months after the secondary ACLR.

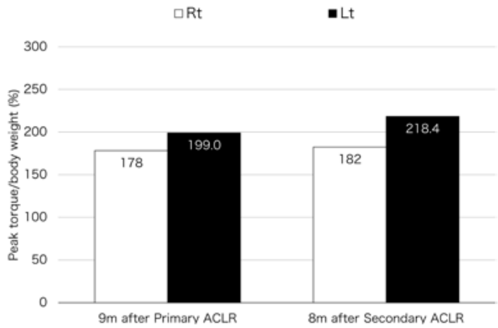

Figure 2. Peak torque-to-body weight ratio at 180°/s (Nm) in extension, measured 9 months after the primary ACLR and 8 months after the secondary ACLR.

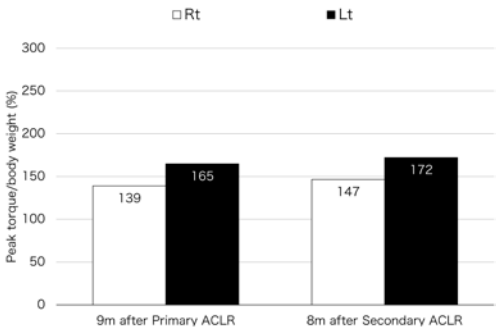

Figure 3. Peak torque-to-body weight ratio at 300°/s (Nm) in extension, measured 9 months after the primary ACLR and 8 months after the secondary ACLR.

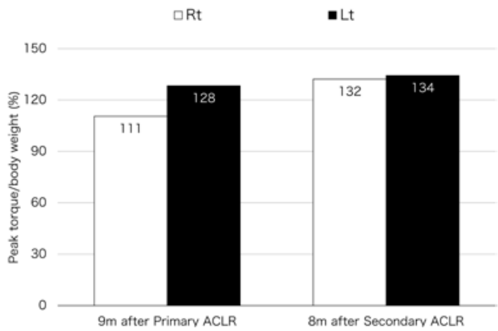

Figure 4. Peak torque-to-body weight ratio at 60°/s (Nm) in flexion, measured 9 months after the primary ACLR and 8 months after the secondary ACLR.

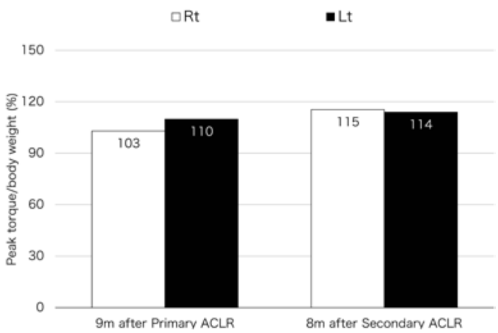

Figure 5. Peak torque-to-body weight ratio at 180°/s (Nm) in flexion, measured 9 months after the primary ACLR and 8 months after the secondary ACLR.

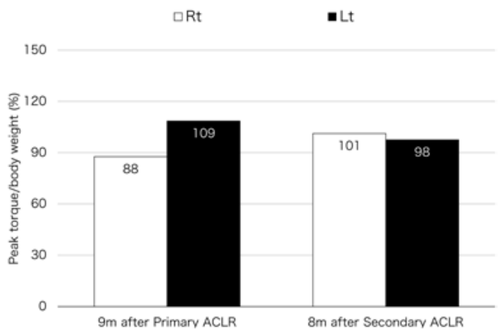

Figure 6. Peak torque-to-body weight ratio at 300°/s (Nm) in flexion, measured 9 months after the primary ACLR and 8 months after the secondary ACLR.

limb was weaker than that of the left at the initial RTS, the knee flexion strength was nearly equal side to side in the second RTS.

The H/Q ratios at 9 months after the primary ACLR and 8 months after ACLR are represented in Figures 7 to 9. For 60°/

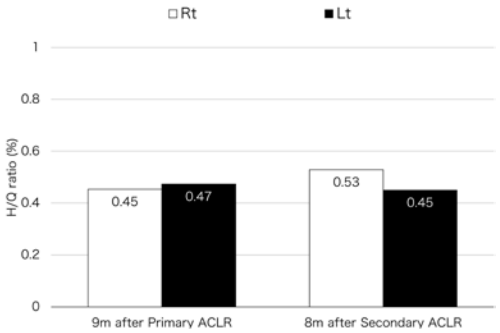

Figure 7. H/R ratio at 60°/s (Nm) 9 months after the primary ACLR and 8 months after the secondary ACLR.

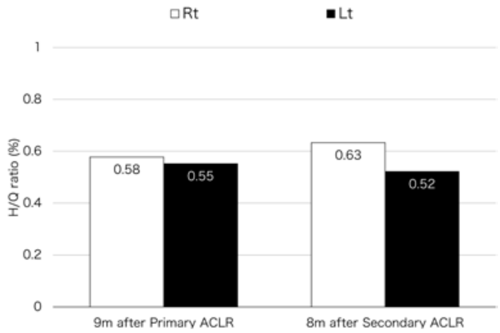

Figure 8. H/R ratio at 180°/s (Nm) 9 months after the primary ACLR and 8 months after the secondary ACLR.

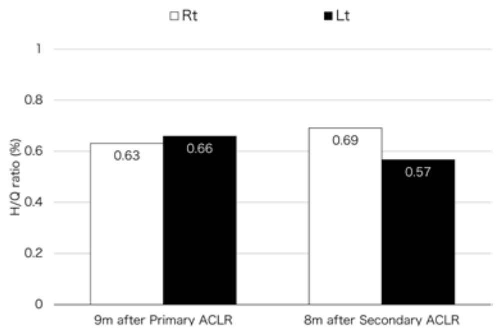

Figure 9. H/R ratio at 300° /s (Nm) 9 months after the primary ACLR and 8 months after the secondary ACLR.

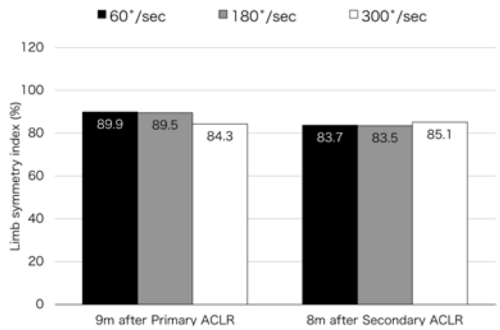

Figure 10. Limb symmetry index scores in the isokinetic extension strength tests, where scores <100% indicate deficits in the right limb.

s, the H/Q ratios ranged from 0.45 to 0.53 at the primary and secondary ACLRs. These results were <0.6, which was the target value.

Figures 10 and 11 show the LSI values for the knee extension and flexion strengths measured at 9 months after the primary ACLR and 8 months after the ACLR at 60°/sec, 180°/sec, and 300°/sec, respectively. An LSI of <100% indicates a deficit in the right limb. For the LSIs on knee extension, data at the secondary RTS indicated <90%. On the other hand, although the LSIs on knee flexion showed ≥90%, these results do not imply a good outcome because of the weakness on both sides.

The knee injury and osteoarthritis outcome score (KOOS) was obtained to assess response to surgery and rehabilitation after ACLR.[10] KOOS is self-administered and assesses five outcomes, namely pain, symptoms, activities of daily living, sport and recreation function, and knee-related quality of life (Figure 12).

DISCUSSION

Female basketball player of this case report fully returned to competition 9 months after the secondary ACLR and

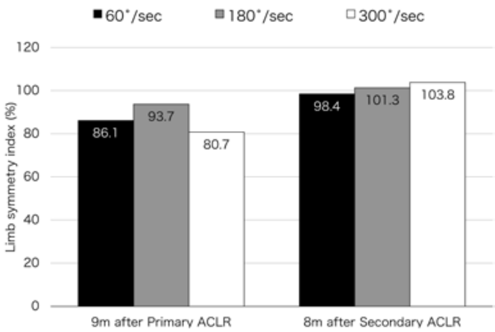

Figure 11. Limb symmetry index scores in the isokinetic flexion strength tests, where scores <100% indicate deficits in the right limb.

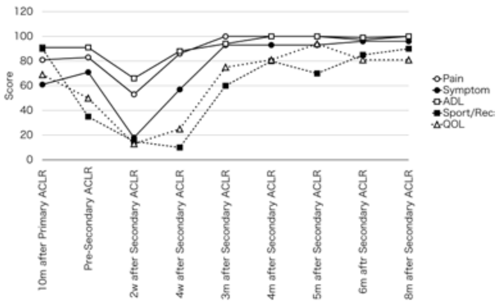

Figure 12. Knee injury and osteoarthritis outcome score (KOOS) profile 10 months after the primary ACLR, before the secondary ACLR, and 2 and 4 weeks, and 3, 4, 5, 6, and 8 months after the secondary ACLR. ADL = activities of daily living. Sport/Rec = sport and recreation function. QOL = knee-related quality of life.

played competitive sports at her preinjury performance level. Female athletes have 3 to 8 times higher incidence of ACL injuries than their male counterparts[6,14]. The causes of secondary ACL rupture are unclear but are likely multifactorial. Considering the current functional performance level, the possibility of a third ACL rupture cannot be denied.

On the basis of the traditional impairment measures such as strength, approximately 90% achieved normal knee function after completing their rehabilitation programs2. Certainly, most patients return to sports at 9 to 12 months after ACLR. However, a systematic review and meta-analysis revealed that 7% of athletes who had had an ACLR had an ipsilateral reinjury and a contralateral injury rate of 8%.[15]

As mechanism of injury in ACL rupture, non-contact ACL injuries are more common, occurring 70% of the time, whereas contact injuries account for the remaining 30%[4]. Noncontact injuries occur most frequently during cutting and pivoting activities that require rapid deceleration[12], change of direction[6], or when landing from a jump on one leg[6]. In this case, the stopping movement involving with rapid deceleration was the cause of ACL injury. Establishing strength milestones during ACL rehabilitation is important because quadriceps weakness can persist for 2 years after surgery[8]. Therefore, to prevent a third ACL rupture, the female basketball player in this case report should improve the raid muscle contraction of the quadriceps and hamstring muscles to display dynamic knee joint stabilization during the initial phase of voluntary muscle contraction.

Athletic trainers should be familiar with healing time frames and graft stresses to prescribe proper exercises at appropriate intervals. Clinical milestones, effusion grading, and soreness guidelines are used to aid clinical decision making regarding exercise progression. Athlete compliance with the exercise program is a major factor in its ultimate success. In a meta-analysis of neuromuscular training programs, Sugimoto et al.[13] suggested that compliance rates should be >66% for these programs to exhibit prophylactic effects. However, athletic rehabilitation programs may not be consistently performed under the direct supervision of the athletic trainer. It is important for the athlete to utilize guidelines for activity progression during this phase. Modified soreness guidelines provide a systematic approach to activity progression and may be applied to each phase of rehabilitation[3]. These rules should be combined with effusion monitoring to direct the athlete' s participation in high-demand functional activities. If the athlete can complete a workout with no soreness during or after the session, it is appropriate to advance to the next level of training.

As previously mentioned in clinical impression, the subject performed dynamic postural control during slow single-leg exercises but was unable to maintain postural control as the movement speed increased. She had poor use of hip and ankle strategies to maintain balance on single-leg stance. Focus on neuromuscular training is important for all exercises. Proper kinematics with low- to high-level exercises should be ensured. Feedback is found to be a crucial component in successful ACL injury prevention programs.[5] Therefore, verbal and manual feedbacks were used to help the patient regain proper movement patterns. Progressions from sagittal plane movements to frontal plane movements (i.e., barrier jumps) and transverse plane movements (180° jump) are typically incorporated throughout a program to challenge multidirectional neuromuscular control.

In the late phase of athletic rehabilitation, the athlete should begin with full-speed agility training, progressing to unopposed practice of sport-specific skills, followed by one-on-one opposed practice of sport-specific skills and then full practice activity with the team. Thus, performance-based testing is important to assess a patient' s readiness to return to higher level, sport-specific activities. Functional testing and outcome measures are performed to assess the athlete's readiness to begin a RTS progression. The single-leg hop test is a straight-line hop for distance, looking at control of landing mechanics and distance. Hop testing is a reliable and valid performance-based outcome measure after ACL reconstruction[7]. For hop testing, the most common return-to-sport criterion is a LSI of 85% to 90%[9,11]. In this case, we failed to perform hop testing, which should always be included in performance assessments.

CONCLUSION

In conclusion, the female basketball player in this report sustained a secondary ACL rupture but returned to sports at her preinjury level. Considering her current functional performance level, a third ACL rupture is possible. To continue competitive activities safely, strengthening both hamstrings and enhancing the raid muscle contraction of the quadriceps and hamstrings may be necessary to display dynamic knee joint stabilization. In addition, the patient should improve her neuromuscular control.

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