



Original Article

Immediate effects of neuromuscular joint facilitation intervention after anterior cruciate ligament reconstruction

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Abstract. [Purpose] The aim of this study was to examine the immediate effects of neuromuscular joint facilitation (NJF) on the functional activity level after rehabilitation of anterior cruciate ligament (ACL) reconstruction. [Subjects and Methods] Ten young subjects (8 males and 2 females) who underwent ACL reconstruction were included in the study. The subjects were divided into two groups, namely, knee joint extension muscle strength training (MST) group and knee joint extension outside rotation pattern of NJF group. Extension strength was measured in both groups before and after the experiment. Surface electromyography (sEMG) of the vastus medialis and vastus lateralis muscles and joint position error (JPE) test of the knee joint were also conducted. [Results] JPE test results and extension strength measurements in the NJF group were improved compared with those in the MST group. Moreover, the average discharge of the vastus medialis and vastus lateralis muscles on sEMG in the NJF group was significantly increased after MST and NJF treatments. [Conclusion] The obtained results suggest that NJF training in patients with ACL reconstruction can improve knee proprioception ability and muscle strength.

Key words: Neuromuscular joint facilitation, Anterior cruciate ligament reconstruction, Proprioception

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INTRODUCTION

The anterior cruciate ligament (ACL) is the most frequently injured knee ligament, accounting for about 50% of all ligament injuries¹⁾. Approximately 91% of ACL injuries occur during sports activities, comprising mostly of noncontact injuries, such as landing from a jump and rapid deceleration²⁾. Patients with ACL injuries often have knee instability, which may change and damage other joint structures and function, thereby affecting daily life activities³⁾. These patients also have difficulty to recover their normal walking abilities and full functions of the lower limbs⁴⁾.

Reconstructive techniques have been recently improved to achieve better stabilization of the knee joint and other joints to gain better functional recovery⁵⁾. The lack of full recovery of knee functions after ACL reconstruction is due to sensory and motor behavior deficits. Moreover, proprioceptive afferent neural input is important in functional control during sports activities⁶⁾. In clinics, patients are often requested to walk normally, but there are few methods to facilitate a normal proprioception during walking training.

In addition to muscle strength, proprioception also decreases in patients with cervical spinal cord injury, stroke, or fracture. The joint position error (JPE) test primarily measures the proprioception of the upper and lower limbs and is widely used as an outcome indicator for patients with cervical spinal cord injury and hemiplegia⁷⁾. A decrease in JPE indicates increased ability to reposition joints after active movements. In clinical treatments and studies, resistance to knee joint flexion is used to enhance the strength of the vastus medialis and vastus lateralis muscles, whereas in clinical treatments, isotonic contraction

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is employed. Evaluation of proprioception is not performed to assess or compare other manipulation therapies⁸⁾.

Neuromuscular joint facilitation (NJF) is a technique that is used to improve the lower-limb muscle strength and gait function. NJF is performed to increase strength, flexibility, and range of motion (ROM). This technique is a new therapeutic exercise based on kinesiology. The elements of proprioceptive neuromuscular facilitation and joint composition movement are integrated in NJF to improve the movement of the joint through passive, active, and resistance exercises⁹⁾.

The emphases of the characteristics of NJF are on end rotation movement and proximal resistance to improve the functions of the knee joint. NJF uses the spiral-diagonal movements as proprioceptive neuromuscular facilitation, but the resistance location of NJF is different. Proximal resistance is applied to the tibial plateau in knee patterns¹⁰⁾.

In clinical studies, the immediate effects of NJF patterns are assessed using the reaction time and extension strength of the knee joint. NJF intervention in knee osteoarthritis improves pain degree and walking ability¹¹⁾.

This aim of this study was to examine the immediate effects of NJF on the functional activity level after rehabilitation of ACL reconstruction.

SUBJECTS AND METHODS

Patients who underwent arthroscopic ACL reconstruction in BOAI hospitals in Beijing, China were recruited between September and December 2015. The patients performed rehabilitation exercises for at least 2 months at the physical therapy department. The subjects were limited to patients who had undergone ACL reconstruction with autografts performed by the same surgeon. The anatomical stability of the selected subjects did not differ based on radiographic and magnetic resonance imaging.

A total of 10 young subjects (8 males and 2 females) were included in this study. The detailed characteristics of the subjects are shown in Table 1. The objective and contents of this study were explained to all subjects prior to participation, and informed consent was obtained. The Research Ethics Committee of China Rehabilitation Research Center (IRB no. 2014-K-005) approved this study.

The subjects sat on high chairs with their hip joints and knee joints at 90° flexion. The subjects' knee joints were out of the high chairs. Two isotonic contractions were performed at knee joint extension on different days, namely, the knee joint extension muscle strength training (MST) and the knee joint extension outside rotation (EOR) pattern of NJF. Resistance was applied to the highest level possible that allowed the subjects to complete the isotonic exercise.

1. MST group: One hand of the examiner was placed against the distal end of the tibia. Resistance was applied as the subjects performed knee joint extension.

2. NJF group: The knee joint EOR pattern of NJF was performed. One hand of the examiner was placed against the distal end of the tibia, while traction and resistance were increased. The examiner's other hand was at the bottom of the lateral tibial plateau as proximal resistance; the tibia was moved distally and internally rotated, while the knee joints were extended. When the subjects performed the knee joint extension pattern, traction and resistance were applied throughout the process using two hands¹²⁾.

Extension strength was measured in both groups before and after the experiment. Surface electromyography (sEMG) of the vastus medialis and vastus lateralis muscles and JPE test of the knee joint were also conducted.

An ROM measurement equipment (BioVal 4.51, SyCoMoRe 8.51, RMIngenierie, France) was used in the JPE test. The fixed and mobile arms were the vertical axis of the femur and the fibula; the flexion angle of the knee joint was recorded by a computer. The subjects were requested to close their eyes, and the examiner flexed the knee joints of the subjects at a random angle. The knee joints of the subjects were then fully extended, and they were requested to flex their knees at approximately the same angle as in the initial flexion. Errors in the knee flexion angle were recorded. Each measurement was conducted five times, and average values were used for the analyses. In the sEMG evaluation of the vastus medialis and the vastus lateralis muscles and the extension strength evaluation of knee joints, the maximum isometric contraction at the starting position was maintained for 5 s. During this evaluation, the average discharge of the muscle was measured with an sEMG system (Telemetry 2400T; Noraxon, Scottsdale, AZ, USA). At the same time, the maximal extensor strength of isometric contraction of the knee joint was measured. An isokinetic dynamometer (Prima Plus, Easytech, Italy) was also used. All measurements were carried out by one physiotherapist.

Two-way ANOVA and Bonferroni multiple comparison test were performed to determine statistically significant differences in the intervention techniques and groups. If a significant interaction was found, paired t-test was performed to compare pre- and post-intervention. Data were analyzed using SPSS Ver. 17.0 for Windows. $P < 0.05$ was considered statistically significant.

RESULTS

Two-way ANOVA revealed significant interactions between the JPEs and the extension strength of the two groups, indicating significantly different changes (Table 2). The error in the knee flexion angle repetition was reduced, and the strength of knee joint extension was increased by NJF intervention.

Table 1. Subject characteristics

	M ± SD N=10
Age (years)	33.1 ± 6.5
Height (cm)	170.5 ± 7.9
Weight (kg)	72.4 ± 21.5

Table 2. Intervention effects of the joint position error (JPE), extensor strength and surface electromyography (sEMG) of different treatments for the knee joint

	a. Befor of MST group	b. After of MST group	c. Before of NJF group	d. After of NJF group	Comparison among groups
The error of elbow flexion angle (°)	7.3 ± 1.9	7.5 ± 1.6	6.9 ± 2.0	3.8 ± 1.2	a,b,c>d**
The sEMG average discharge of the vastus lateralis (µv)	135.4 ± 48.6*	190.3 ± 63.9*	150.4 ± 39.7*	210.3 ± 58.8*	a<b*, c<d*
The sEMG average discharge of the medial vastus muscle (µv)	160.3 ± 31.2*	201.7 ± 29.5*	173.4 ± 44.9*	206.7 ± 21.7*	a<b*, c<d*
The maximum discharge of extensor strength (NM)	49.7 ± 4.6	45.3 ± 5.1	46.1 ± 4.5	58.1 ± 5.6	a,b,c<d**

*p<0.05; **p<0.01

MST: muscle strength training; NJF: neuromuscular joint facilitation

Two-way ANOVA showed major effects of the intervention on sEMG. The paired t-test exhibited a significant increase in the average discharge of the vastus medialis and the vastus lateralis muscles on sEMG after the intervention. However, significant difference was not found between the MST and the NJF groups.

DISCUSSION

JPE test results and extension strength measurements in the NJF group were improved compared with those in the MST group. Moreover, the average discharge of the vastus medialis and the vastus lateralis muscles on sEMG in the NJF group was significantly increased after both MST and NJF treatments.

The aforementioned results were attributed to the excitability of proprioception in NJF compared with the knee joint extension. This excitability of proprioception effectively adjusted the movement of lower limbs after ACL reconstruction by proximal resistance and the end rotation movement of knee joints.

The treatments exhibited similar results on the sEMG of the vastus medialis and the vastus lateralis muscles, but the extension strength was improved by NJF intervention. This result could be attributed to the improvement in functions of the periarticular muscles and the alignment of the knee joint capsule by applying proximal resistance.

The results of this study suggest that knee proprioception ability and muscle strength can be improved by NJF training in patients with ACL reconstruction. Future studies are necessary to investigate the effects of long-term NJF intervention on walking ability in patients with ACL reconstruction.

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