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Effects of Lumbar Mobilization and Transcutaneous Electrical Nerve Stimulation on Proprioception and Muscular Strength in Volleyball Players with Chronic Knee Pain

Background: The spinal nerves, which start at the lumbar level, are connected to the nerve innervation in the knees. Currently, there is a lack of research on the treatment of knee pain through lumbar mobilization.
Objectives: To investigate the effects of lumbar joint mobilization (LJM) and transcutaneous electronic nerve stimulation (TENS) on proprioception and muscular strength in volleyball players with chronic knee pain.
Design: Two group pre-posttest.
Methods: A total of 26 professional volleyball players with chronic knee pain were allocated to the LJM (n=13) and TENS (n=13) groups. In the LJM group, grade III - IV amplitude was applied 3 times for 1 minute (80 times per minute) at the affected lumbar (L2-3) facet joint in the prone position. In the TENS group, the TENS treatment device was used to directly apply or 15 minutes to the area of chronic knee pain (100 Hz, 150 ㎲). Proprioception was measured by knee flexion and extension angles, and muscle strength was evaluated using an isokinetic test. Measurements were taken before and after interventions.
Results: In the eye opened conditiond, proprioception significantly increased during both knee extension and flexion after LJM, while only knee extension was significantly increased in the TENS group. There was also a significant difference in knee extension between the two groups. In the eye close conditiond, proprioception was significantly improved only during knee extension in the LJM group, and the difference in knee extension between the groups was also significant ($P<.05$). The maximum torque of the affected knee joint was significantly improved at 60°/sec in both groups ($P<.05$); however, there was no difference between the two groups. There was no significant difference in the maximum flexion torque within or between the groups.
Conclusion: This study suggests that LJM improved proprioception and muscular strength in volleyball players with chronic knee pain.

Keywords: *Volleyball; Knee pain; Lumbar mobilization; TENS; Proprioception; Muscular strength*

Ilhwan Ahn, PT, MS[a], Hojung An, Prof., PhD[b]

[a]Medical part, Wooricard Volleyball team, Seoul, Republic of Korea
[b]Department of Physical Therapy, Dongnam University, Suwon, Republic of Korea

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Address for correspondence
Hojung An, Prof., PhD
Department of Physical Therapy, Dongnam Health University, 50, Cheoncheon-ro 74, Jangan-gu, Suwon-si, Gyeonggi-do, Republic of Korea
Tel: ***-****-****
E-mail: ans628@dongnam.ac.kr

INTRODUCTION

Volleyball is one of the most popular sports worldwide.[1] In volleyball, specific moves, such as jumping, landing, blocking, and spiking the ball require a combination of fast movements of the musculoskeletal system, which leads to a high risk of musculoskeletal injuries in volleyball players.[2] In a study of 94 injured volleyball players in South Korea, injuries were most commonly observed in the knee (25.9%), lower back (13.3%), and elbow and ankle (8.4%), and the main tissues affected were of the joints (41.6%) and muscle (30.7%).[3] In particular, patellofemoral pain syndrome (PFPS) is the most common overuse syndrome in athletes,[4] which is caused by overuse and overload as well as biomechanical or muscular changes in the patellofemoral joint. PFPS is characterized by retropatellar (behind the kneecap) or peripatellar (around the kneecap) pain.[5]

The treatment of PFPS includes patient education, activity modification, neuromuscular electric stimulation of the quadriceps, therapeutic ultrasound, biofeedback, activity enhancing exercises the of vastus medialis obliques muscle, lower extremity strengthening exercises, proximal stabilization, stretching of tight structures, bracings, foot orthoses, manual therapy, and kinesiotaping.[5-10] These therapeutic approaches are applied directly or indirectly proximal to the area of pain.

Conversely, indirect therapeutic interventions, applied to a remote area rather than the area of pain, can be performed. Cervical and thoracic spine manipulation has been shown to improve shoulder pain. This improvement is believed to be due to neurophysiological effects,[11,12] where the flow of sensory information to the nervous system alters motoneuron excitability and increases pain tolerance or thresholds.[13-15] Other studies have investigated lumbar mobilization in patients with knee osteoarthritis.[16] However, in general, there is a lack of evidence for the therapeutic effects of indirect interventions.

Therefore, the purpose of this study was to assess the effects of lumbar mobilization on proprioception and muscle strength in professional volleyball players with chronic knee pain to provide basic data for future interventions in volleyball players with chronic knee pain.

SUBJECTS AND METHODS

Subjects

In this study, 26 male professional volleyball players from the Korea Professional Volleyball Federation between the age of 20 and 40 who were currently active, had more than 10 years of athletic experience, and had chronic knee pain were selected. Voluntarily signed written consent to participate in the study was collected from all participants before conducting the study. This study was approved by the Institutional Review Board of Namseoul University (NSUIRB-202003).

The selection criteria of research subjects were as follows: (1) individuals who had been diagnosed with PFPS as the cause of knee pain; (2) persistent knee pain for more than 6 months at the time of the study; and (3) able to actively extend the knee of the affected side more than 160° and perform a deep squat. The exclusion criteria of study subjects are as follows: (1) individuals who developed edema of the joints after exercise at the time of the study and (2) inability to participate in team practice due to pain at the time of the study. This was a blinded study where the measurer and mediator, both of whom were physical therapists with more than 5 years of clinical experience, were separated to restrict their interactions. The subjects were randomly assigned to the groups.

The general characteristics of the study subjects in each group are shown in Table 1.

Intervention

Lumbar mobilization

Maitland's oscillation technique was used in this study[17] where grade III-IV amplitude was applied to the facet joint area of the affected lumbar (L2-3) in the prone position. The therapist stood on the affected side of the subject as LJM was performed three times at the same mobilization speed (80 times/min) and for the same duration (1 min) for each area. A break of 10 seconds was provided between measurements of each area, and the break time between each set was 1 minute. The treatment was provided once (Figure 1).

Table 1. General characteristics of subjects

	TENS (M ± SD)	LJM (M ± SD)	*P*
Age (years)	29.08 ± 4.27	29.69 ± 5.17	.744
Height (cm)	191.85 ± 6.44	191.77 ± 8.05	.979
Weight (kg)	87.77 ± 7.19	85.08 ± 8.60	.395
Career (years)	17.38 ± 4.74	17.69 ± 4.27	.863

TENS: Transcutaneous electrical nerve stimulation
LJM: Lumbar joint mobilization

Figure 1. Application of lumbar mobilization

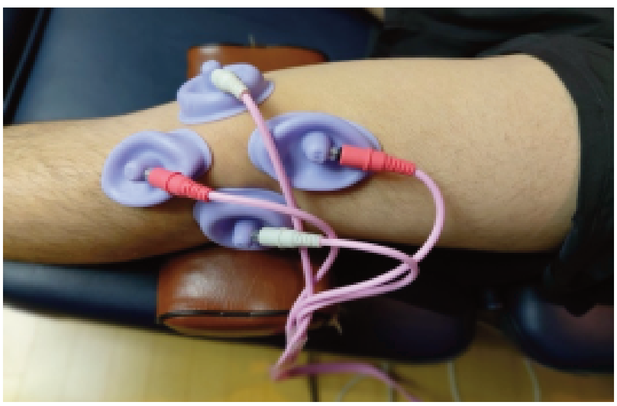

Figure 2. Application of TENS

TENS

In the TENS group, a TENS treatment device (Nihon Medix, Japan) was used to directly apply current with a frequency of 150 ㎲ at 100 hz for 15 minutes to the chronic knee pain area (Figure 2).

Measurements

Proprioception

Proprioception was measured using an electronic goniometer (Sinson, Digital level DWL-80E, Singapore) in knee extension and flexion positions. For both measurements, the starting angle was 90° of flexion. The target angle of measurement was set to 180° for knee extension and 150° for knee flexion. In both positions, a measurement was made at the point that was 1/3 of the distance from the center of the ankle in the middle of the tibia to the knees (Figure 3). The subjects were allowed to practice twice to learn the maximum extension angle and maximum flexion position, and the angle was measured after maintaining the maximum angle for 2 seconds. To eliminate learning effects in the subjects, a break of 1 minute was provided after the practices. For the measurements, the maximum extension and flexion angles were repeated three times in eye open and close conditions, and the mean value was used in data analysis. A break of 5 seconds was provided between each measurement.

Figure 3. (A) Proprioception extension posture and (B) proprioception flexion posture

Muscular strength

Isokinetic measurements (maximum muscle strength and muscle-endurance measurements) were carried out using HUMAC NORM (CSMI, U.S.I). Quadriceps and hamstring muscle concentric peak torque of both the knee with and without pain were measured 4 times at an angular velocity of 60°/sec and 20 times at 180°/sec. To prevent injury during measurement, aerobic exercise was performed for 10 minutes using an ergometer bicycle as a warm-up prior to measurements, followed by 5 minutes of stretching. Muscle strength was measured afterwards, and the examiner actively encouraged the subject to exert their maximum strength. The range of motion of the joint for the measurement was limited to 0° of extension and 90° of flexion, and the torso, waist, and thigh of the subjects were strapped in place (Figure 4). A preliminary practice was carried out to prevent injuries and increase the proficiency of the isokinetic measurements, and measurement was carried out after 3 minutes of rest. After pre-measurements, post-measurements were done after 24 hours of rest to prevent muscle weakness due to muscle fatigue. Each measurement was performed once.

Figure 4. CSNMI muscular strength posture at (A) extension 0° (B) flexion 90°

Data and statistical analysis

In this study, SPSS version 23.0 (SPSS Inc., Chicago, Illinois) was used for data analysis. Descriptive statistics were performed for all data, and the normality of the variables was assessed using the Shapiro-Wilk test. An independent t-test was performed to compare the study variables between the groups, and a paired t-test was performed for intra-group comparison before and after the intervention. The level of statistical significance for all data was set to $<.05$.

RESULTS

Changes in proprioception

Changes in proprioception in the eye opened condition are shown in Table 2. There was a significant decrease in sensory error during knee extension after intervention in both the TENS and LJM groups compared to before intervention ($P<.05$). During knee flexion, there was a significant decrease in sensory error after intervention in the LJM group compared to before intervention ($P<.05$). The intra-group comparison before and after interventions showed a significant difference between the groups during knee extension ($P<.05$). The changes in proprioception in the eye closed condition are shown in Table 2. During knee extension, there was a significant decrease in sensory errors after intervention in the LJM group ($P<.05$). The intra-group comparison before and after intervention showed a significant difference between the groups during knee extension ($P<.05$).

Changes in muscle strength (changes in the maximum torque of the knee joint)

Changes in the maximum torque during knee joint extension are shown in Table 3. During extension of the affected knee at an angular velocity of 60°/sec, there was a significant increase in the maximum

Table 2. Changes in proprioception

Variable		TENS		P	LJM		P	Between group (P)
		pre	post		pre	post		
EO	KE	13.55 ± 2.67	12.19 ± 2.69	.000*	12.61 ± 3.91	9.04 ± 4.70	.001*	.011*
	KF	18.54 ± 2.70	18.24 ± 2.30	.232	20.61 ± 4.58	20.25 ± 4.47	.012*	.809
EC	KE	15.01 ± 3.58	13.78 ± 2.53	.101	14.24 ± 3.89	10.53 ± 4.98	.001*	.025*
	KF	19.13 ± 3.14	18.24 ± 3.62	.085	20.79 ± 5.51	20.28 ± 4.38	.241	.549

*$P<.05$, EO: Eyes open, EC: Eyes closed, KE: Knee extension, KF: Knee flexion
TENS: Transcutaneous electrical nerve stimulation, LJM: Lumbar joint mobilization

Table 3. Changes in proprioception

Variable		TENS		P	LJM		P	Between group (P)
		pre	post		pre	post		
KE	60°/sec	254.38 ± 62.55	261.23 ± 57.64	.017*	256.15 ± 41.76	266.85 ± 43.99	.003*	.327
	180°/sec	168.77 ± 35.21	171.23 ± 35.44	.170	185.54 ± 37.11	187.31 ± 36.62	.218	.752
KF	60°/sec	143.54 ± 24.97	140.31 ± 30.65	.450	150.31 ± 30.29	152.46 ± 28.00	.322	.257
	180°/sec	117.31 ± 15.18	112.54 ± 18.76	.386	115.38 ± 22.75	117.15 ± 19.98	.498	.276

*P<.05, KE: Knee extension, KF: Knee flexion
TENS: Transcutaneous electrical nerve stimulation, LJM: Lumbar joint mobilization

torque after intervention in both groups (P<.05). In contrast, the maximum torque did not undergo significant changes during flexion of the knee joint (Table 3).

DISCUSSION

The purpose of this study was to assess the effects of LJM and TENS on proprioception and muscular strength in volleyball players with chronic knee pain. In the studies on proprioception, significant improvements in proprioception were observed after LJM. These effects are believed to be neurophysiological responses due to mobilization. Previous studies have demonstrated that spinal mobilization causes changes in the sympathetic nervous system (SNS), which stimulates the dorsal periaqueductal region of the brain and causes SNS responses.[18-20] These SNS responses lead to benefits in manual mobilization including analgesia, sympathoexcitation, and motor facilitation.[21] In addition, joint mobilization includes central mechanisms, such as facilitation of descending inhibitory pathways from a high level (i.e., the brainstem), inhibitory pathways from the spinal cord, as well as local physiological mechanisms.[22] In a related study, mobilization of the cervical spine was shown to reduce hyperalgesia of the upper limbs.[21] Previous studies have demonstrated that pain affects not only muscle strength, but also proprioception.[23-25] Therefore, it is thought that LJM causes a neurophysiological reaction of the central nervous system, suppressing pain in the knee and thereby improving proprioception in our study.

Our findings on muscular strength suggest that LJM leads to a significant increase in the maximum torque during extension of the affected knee at 60°/sec after intervention. Joint mobilization and manipulation are known to alter muscle activation in both near and distant areas from the site of intervention.[26-30] For example, in the lower limb, the sacroiliac joint (L2–S3), quadriceps (L2–4), and knee joints (L2–S2) share the common nerve root levels, and afferent information of one structure can alter the efferent signals of all structures that a similar nerve root level innervates.[31] In a study by Grindstaff, lumbopelvic manipulation showed changes in voluntary quadriceps activation, which lasted up to 20 minutes.[30] Additionally, single lumbopelvic joint manipulation in those with pain in the anterior part of the knee increased quadriceps force output[32] and quadriceps activation.[33] The quadriceps acts as an extension of the knee joint and are controlled by the femoral nerves, which are formed from the nerve roots of L2–L4.34 In our study, LJM was applied to the affected facet joint in L2–L3. It is thought that the quadriceps were activated due to the association between the site of LJM and nerves in the knee joint, leading to an increase in the extension torque of the knee.

Overall, the findings of our study suggest that LJM is a useful intervention for the improvement in athletic performance in volleyball players with chronic knee pain. However, LJM was only performed once, and thus, the continuous effects of LJM could not be assessed. In future studies, it would be necessary to increase the duration of the intervention.

CONCLUSION

This study suggests that LJM improved proprioception and muscular strength in volleyball players with chronic knee pain. These findings confirm the possibility of LJM as a clinical intervention for chronic knee pain in volleyball players.

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