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Original Article

Effects of eccentric control exercise for wrist extensor and shoulder stabilization exercise on the pain and functions of tennis elbow

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Abstract. [Purpose] This study aimed to conduct experiments to examine the effects of wrist eccentric control exercise or shoulder stabilization exercises after a basic direct treatment of the elbow in the treatment of tennis elbow patients in terms of pain and grip strength. [Subjects and Methods] The subjects were divided into two groups: one group conducted wrist eccentric control exercise and was comprised of 5 male and 4 female subjects, and the other group received shoulder stabilization exercise and was comprised of 5 male and 4 female subjects. [Results] In the intragroup comparison, both groups showed a significant decrease in pain level and a significant increase in the measurement of the tenderness thresholds of the upper trapezius muscle, lateral epicondyle, and grip strength. In the intergroup comparison, the shoulder stabilization exercise group showed a significantly greater increase in the measurement of the tenderness thresholds of the upper trapezius muscle and grip strength, and the differences were not significant in the pain level and tenderness threshold of the lateral epicondyle. [Conclusion] Wrist eccentric control exercise and shoulder stabilization exercises can be useful as intervention methods for relief from pain due to lateral epicondylitis and for the improvement of functions impaired by tennis elbow.

Key words: Tennis elbow, Wrist eccentric control exercise, Shoulder stabilization

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INTRODUCTION

Tennis elbow causes pain during wrist extension, finger extension, and forearm eversion resistance as well as reduces grip strength and extremity loading resistance, particularly during elbow extension[1)]. Lateral epicondylitis is known as tennis elbow, and the pain is caused by damage to the tendon of the short radial extensor of the wrist on the lateral side of the elbow[2)]. Relevant risk factors include overuse, repetitive movements, wrong training, misalignment, flexibility problem, age, poor circulation, muscle weakening or imbalance, and mental factors[3, 4)]. In addition, tennis elbow is usually related to individuals' repetitive occupations or hobbies[5)].

Patients with pain in the lateral epicondyle show increased pain and decreased functional abilities and grip strength due to the weakening of the rotator cuff and the scapula muscular systems[6)]. Functional impingements of the shoulder joints occur because of the excessive compensation of the extensor resulting from impaired shoulder stability attributable to changes in the joint dynamics and muscle imbalance. As a result, the symptoms of tennis elbow appear because of minute damage to the elastic tissues. Overload due to repetitive forearm movements leads to changes in the shoulder complex and the symptoms of lateral epicondylitis appear because of the resultant forearm and hand muscle overload[7)]. The primary purposes of the treatment of tennis elbow are pain relief, movement preservation, and enhancement of flexibility, muscle strength, and endurance[8)]. In particular, with regard to the effects of treatment, eccentric muscle contraction exercise provides substantial

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stimulation to the tendon cells that generate collagen and enables the tendons to gain more power during activities, thereby tolerating pressure[9, 10].

Shoulder stabilization exercise focuses on the recovery of balance among the shoulder stabilizing muscles. Closed chain exercises have been recently used as therapeutic exercises for the upper extremities[11]. Push-up plus exercises are performed as closed chain exercises of the upper extremities, and they are widely used by subjects with shoulder problems as therapeutic exercises for the improvement of shoulder functions because they are easy as strengthening exercises for the muscles around the shoulder[12]. In addition, among closed chain exercises, sling exercises can increase loads step by step, increase muscle strength, and improve proprioceptive sensibility[13]. In the case of the rehabilitation of patients with instability of the shoulder, training on unstable bearing surfaces leads to the recovery of the balance of proprioceptive sensibility[14].

Shoulder stability is important for upper extremity functions. Many previous studies focused on the elbow only for the treatment of lateral epicondylitis patients, and studies on the stability of the shoulder of tennis elbow patients are rare. Therefore, this study aimed to conduct experiments to examine the effects of wrist extensor eccentric control exercise or shoulder stabilization exercise after a basic direct treatment of the elbow in the treatment tennis elbow patients in terms of pain and grip strength.

SUBJECTS AND METHODS

The present study was conducted on tennis elbow outpatients in their 20s–50s of K Clinic located in Andong, Gyeongsangbuk-do. Among the patients, those with tennis elbow for five months or longer, those that took drugs or had injections because of tennis elbow, those that experienced neurologic symptoms in their upper extremities, and those that could not perform exercises were excluded from the study. A total of 18 subjects participated in the study, and the subjects were divided into two groups through random assignment with lot drawing: the wrist extensor eccentric control exercise group with five male and four female subjects and the shoulder stabilization exercise group with five male and four female subjects. The research design targeted patients at the hospital field, applying both existing conservative treatments and applying additional exercise interventions. Before performing the exercises, the wrist extensor eccentric control exercise group and the shoulder stabilization exercise group underwent basic hyperthermia for 20 min, transcutaneous nerve simulation treatment for 15 min, and massage and stretching for 5 min. The study was conducted after obtaining the consent on the purpose and progression of the study from all subjects and approval from the institutional review board of Daegu University (1040621-201705-HR-009-02).

The wrist extensor eccentric strengthening exercise group performed wrist muscle eccentric contraction exercises using Thera bands, with the affected side forearm in the state of internal version made after placing the forearm on the edge of the bed and with the hand placed outside the bed. The exercises were performed slowly while extending the affected side hand using the unaffected side hand during wrist extension and assisting the affected side hand using the unaffected side hand during eccentric control exercise, so that the eccentric control exercise could be performed within the range where there was no pain. The exercise performed 15 times was equivalent to one set, and five sets were performed with a break of 1 min after each set.

The shoulder stabilization exercise group performed the push-up plus exercise using slings[15]. In a crawling position as the starting position, the subject held the handle of the sling, which was at a height of 10 cm from the floor; maintained the angle between the shoulder joint and the knee joint at 90°; maintained the head, spine, and pelvis to form a straight line; maintained eye contact with the floor; and placed the hands and knees at shoulder width. The elbows were maintained completely extended, and the ankle joints were maintained in plantar flexion. During the push-up plus exercise, the unciform bones of the middle fingers were aligned with the acromions, and the scapulae were maximally protracted so that the head and the trunk joints formed straight lines. This posture was maintained for 5 s. The exercise performed five times was equivalent to one set, and five sets were performed with a break of 1 min after each set. These interventions were conducted three times a week for three weeks for both groups.

To evaluate the effects of the interventions on the two groups, the visual analogue scale, digital sense of pain, and grip strength were evaluated before and after intervention. The pain levels were measured before the intervention and three weeks later by having the subjects firsthand check the positions corresponding to their pain on a scale of 0 (the state of no pain) to 10 (the state in which unendurable pain was felt).

The threshold of tenderness due to lateral epicondylitis was measured in units of N/cm^2 using a digital algometer on the tenderness points in the upper trapezius muscle and the lateral epicondyle of the shoulder. The threshold of tenderness of the upper trapezius muscle was measured in a comfortable sitting position and that of the lateral epicondyle was measured when the arm was comfortably placed on the bed. The subjects were instructed to make an “ah” sound when they felt pain while pressure was being applied. The pressure at which pain began to be felt was measured three times with an interval of 1 min after each measurement. In addition, the position of measurement was marked to prevent the position from changing during the measurements and the subjects from knowing the measurement results.

Grip strength was measured using a digital grip dynamometer DW701 (Takei Inc., Japan). The grip dynamometer was placed on the second knuckle of the finger to measure the grip strength between the thumb and other fingers, and the subject gripped the grip dynamometer for 5 s within the range where no pain was felt, with both arms naturally lowered while

Table 1. The general characteristics of the subjects

	WECEG (n=9)	SSEG (n=9)
Age (yrs)	46.0 ± 5.2	46.7 ± 6.1
Height (cm)	168.9 ± 9.7	166.6 ± 10.2
Weight (kg)	64.0 ± 10.1	65.4 ± 10.5

Mean ± SD. WECEG: Wrist eccentric control exercise group; SSEG: Shoulder stabilization exercise group.

Table 2. Intragroup and intergroup comparisons (unit=scores)

Group		Before	After	Change
WECEG	VAS	5.3 ± 1.1	2.0 ± 1.2*	−3.3 ± 1.0
	PPT (UT)	9.1 ± 2.2	11.2 ± 2.3*	2.1 ± 0.6
	PPT (WE)	4.0 ± 1.4	5.0 ± 1.8*	0.9 ± 0.5
	PFGS	24.1 ± 5.7	30.2 ± 6.7*	6.1 ± 2.8
SSEG	VAS	6.3 ± 0.3	2.4 ± 0.4*	−3.9 ± 0.8
	PPT (UT)	8.2 ± 0.6	11.8 ± 0.8*	3.6 ± 1.2†
	PPT (WE)	3.5 ± 0.5	4.9 ± 0.7*	1.4 ± 0.7
	PFGS	22.5 ± 3.0	31.8 ± 2.8*	9.3 ± 2.6†

Mean ± SD. *$p<0.05$, †Significant difference between groups ($p<0.05$).
WECEG: Wrist eccentric control exercise group; SSEG: Shoulder stabilization exercise group; VAS: visual analogue scale; PPT (UT): pain pressure threshold (Upper trapezius); PPT (WE): pain pressure threshold (Wrist extensor); PFGS: Pain free grip strength.

ensuring that the grip dynamometer was not shaken or put into contact with the body. This measurement was conducted three times and the average value was used.

Data were analyzed using Window SPSS version 18.0 (SPSS Inc., Chicago, IL, USA). Wilcoxon signed-rank tests were conducted to compare the states between before and after intervention in each group. Mann-Whitney U tests were conducted for the intergroup comparison to determine the differences between the two groups. $P<0.05$ was set for all analyses and the significance level was set to $\alpha= 0.05$.

RESULTS

The general characteristics of the subjects are presented in Table 1.

In the intragroup comparison, both groups showed a significant decrease in pain level and a significant increase in the measurement of the tenderness thresholds of the upper trapezius muscle, lateral epicondyle, and grip strength. In the intergroup comparison, the shoulder stabilization exercise group showed a significantly greater increase in the measurement of the tenderness thresholds of the upper trapezius muscle and grip strength, and the differences were not significant in the pain level and tenderness threshold of the lateral epicondyle (Table 2).

DISCUSSION

To clinically relieve the symptoms of tennis elbow patients, Sharma et al. compared the effects of rotator cuff strengthening/ultrasonic therapy and rotator cuff strengthening/wrist extensor eccentric contraction exercise, among all other intervention methods, for different periods, and both groups showed significant pain relief when pain was measured three weeks after beginning the interventions[16]. In this study, wrist extensor eccentric muscle contraction exercise also showed significant pain relief after intervention. Given the foregoing, the eccentric control exercise stimulated the mechanoreceptors in the tenocytes, thus leading to the generation of collagen and recovery from tennis elbow accompanied by pain relief[17]. The shoulder stabilization exercise also showed significant pain relief after intervention. The symptoms of lateral epicondylitis appear because of changes in the shoulder complex and the compensatory actions caused by the overload of the forearm muscles resulting from repetitive movements of the forearm and the hand[7]. The push up plus exercise using a sling is considered to have increased the activity of the muscles around the scapula[18], thus leading to pain relief. However, no significant difference was found in the intergroup comparison.

In the measurement of the thresholds of tenderness in the upper trapezius muscle due to lateral epicondylitis, both groups showed significant increases after intervention. Consistent with the results of Sharma et al., the significant increases in the

threshold of shoulder tenderness seemed to have appeared because the wrist extensor eccentric contraction exercise and the scapula stabilization exercise relieved the symptoms of lateral epicondylitis[16]. The wrist extensor eccentric contraction exercise reduces the pressure load on musculotendinous units, increases tension, and reduces pressure on the tendon during movements[19]. In addition, the scapula stabilization exercise using a sling is a closed chain exercise considered to stimulate the proprioceptors of the joints, increase the axial loads, and assist muscle contraction to maintain posture and provide dynamic stability[20]. It helps the shoulder stability of lateral epicondylitis patients to increase the threshold of shoulder tenderness. However, in the intergroup comparison of the thresholds of upper trapezius muscle tenderness, the threshold of the scapula stabilization exercise group was significantly higher. The overcompensation of the wrist extensor leads to an imbalance between shoulder joint dynamics and muscles, thus resulting in the impingement of scapula stability[7]. Moreover, symptomatic shoulder pain occurs because of the decreased activity of the muscle serratus anterior and the increased activity of the upper trapezius muscle[21]. Many studies indicated that the application of scapula stabilization exercise on unstable bearing surfaces relieved the symptoms because of the decreased activity of the muscle serratus anterior and the increased activity of the upper trapezius muscle[22], thereby relieving pain.

In the intragroup comparison of the thresholds of tenderness of the lateral epicondyle, both groups showed significant increases. However, no significant difference was found in the intergroup comparison. According to recent theories, eccentric muscle contraction exercise is effective in neovascularization, which is a factor of the causes of tendinopathies with pain[23], and low-intensity eccentric exercise reduces the dynamic sensitivity of deep tissues to enhance the threshold of tenderness[24]. In addition, among scapula stabilization exercises, rehabilitation exercises and muscle strengthening exercises on unstable bearing surfaces increase the activity of muscles, enable exercises at high levels of difficulties, and improve the balance of the proprioceptors of the joints[25]. Vicenzino et al. indicated that in the interventions for lateral epicondylitis patients, the experimental group that performed the Mulligan lateral mobilization of the proximal forearm showed more significant increases in the threshold of the lateral epicondyle as treatment effects than the placebo group and the control group[26].

In grip strength measurements, the eccentric muscle contraction exercise group and scapula stabilization exercise group showed more significant increases after intervention than before intervention. In the intergroup comparison, the group that performed the scapula stabilization exercise showed significantly more increases. Grip strength is measured as one of the evaluations of lateral epicondylitis patients. Pain relief or an increase in force leads to increased grip strength[27]. Eccentric exercise is considered to increase blood flow, prevent injury to the damaged area, and cause neovascularization[28], thereby leading to pain relief resulting from the increased grip strength. Scapula stabilization exercise can improve the balance of shoulders kinematically impaired because of the overuse of the elbow and thus lead to increased grip strength[29]. Sharma et al. conducted a survey on the Patient-rated tennis Elbow Evaluation Questionnaire to evaluate the pain, grip strength, digital tenderness threshold, and tennis elbow of an eccentric contraction exercise group and a rotator cuff strengthening exercise group by comparing the before and after intervention and found that the latter group showed significantly more increases than the former only in the measurement of grip strength[16].

In conclusion, wrist extensor eccentric strengthening exercises and scapula stabilization exercises can be useful as intervention methods for relief from pain due to lateral epicondylitis and for the improvement of functions impaired by lateral epicondylitis.

Conflict of interest

None.

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