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# The Effects of Vibration Exercise after Modified BrÖstrom Operation in Soccer Players with Ankle Instability

Background: Vibration exercise after ankle surgery improves proprioception and ankle muscle strength through vibration stimulation.
Objective: To examine the effects of vibration exercise on the ankle stability.
Design: Randomized controlled clinical trial (single blind)
Methods: Twenty soccer players were randomly divided into experimental group and control group. The Vibration exercise program was conducted 12 weeks and 3 times a week. Ankle joint proprioceptive sensory test and Isokinetic muscle strength test were performed using Biodex system pro III to measure plantar flexion / dorsiflexion and eversion / inversion motion.
Results: The result of isokinetic test of ankle joint is showed significant improvement in all measurement items, such as leg flexion, lateral flexion, external and internal muscle forces, compared to previous ones by performing vibration movements for 12 weeks. However, in the comparison group, plantar flexor (30˚), eversion muscle (120˚), inversion (30˚) of limb muscle strength were significantly improvedcompared with the previous phase; was no significant difference in dorsi-flexion. There was no significant difference between groups in all the items.
Conclusions: In this study, we analyzed the effects of rehabilitation exercise on soccer players who had reconstructed with an ankle joint ligament injury through vibration exercise device. As a result, we could propose an effective exercise method to improve the ability, and confirmed the applicability as an appropriate exercise program to prevent ankle injuries and help quick return.

Key words: *vibration exercise, Bröstrom operation, Soccer players, Ankle instability*

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## INTRODUCTION

Soccer have been represented high injury rates due to its characteristic actions such as race rules, speed, sudden acceleration, directional change, shooting and tackle, etc., where contact between players is allowed [1]. Injuries are frequent in the lower extremities, especially in the ankles, with double ligament injuries accounting for more than 85%, and external ligament damage overwhelmingly high [2]. Damage to ankle ligaments can be improved early on through proper preservation, but 10 to 30 percent of soccer players are subject to chronic ankle joint instability, making it difficult to avoid any lack of motor skills [3]. Although the final consideration to address functional improvement and joint instability after ankle injury is surgery, various surgical methods are applied, Bröstrom formulas are most widely implemented [4, 5]. The procedure is reconstructed by reattachment of the external ligament using a suture screw, which can secure biomechanical strength of the ligament suture with excellent clinical results. Therefore, the athlete who has more stable stability in the ankle joint needs joint instability [6].

Ankle joint instability is a consequence of repeated ankle sprains, as well as structural instability of the

ligaments, and a sense of place break, such as a feeling of wobbling or falling joints during exercise, which may result in muscle, ligament weakness, dry motor neuron failure, and is a fatal condition for athletes [7]. There is a method to improve ankle joint instability, rehabilitation exercises must be combined with medical treatment. Many studies have reported the effects of various types of rehabilitation exercises, such as elastic band movements, resistive movements using tools, and aquatic exercise among others, in patients with ankle joint instability [8, 9, 10].

The rehabilitation exercise program for ankle instability should emphasize the postural stability and coordination such as balance sense, proprioceptive sensation, and reinforcement of surrounding muscles including fibular muscle, and exercise in a static posture rather than dynamic posture and help reduce psychological anxiety from previous experiences of injury [11]. Considering these aspects applying a rehabilitation exercise program through vibration stimulation in a static posture to the soccer players who underwent surgery with ankle external ligament injury is considered useful, and some results have been reported [12]. However, most of the previous studies reported so far have been focused on the effects of rehabilitation exercise programs in combination with conservative treatment, and few studies have applied vibrational exercises to soccer players who have undergone surgery. Furthermore, considering the clinical results and various reports of various surgical treatments for the treatment of chronic ankle instability, the postoperative rehabilitation exercise must be applied to improve the ankle instability Research and reports on this subject are very limited. This study analyzes the effects on motor function of ankle joint by applying the Brostrөm procedure a man rehabilitation program that utilizes vibration exercise equipment intended for amateur football players underwent ligament reconstruction with modified ankle lateral ligament injuries and to be a basic research for effective rehabilitation exercise program.

## SUBJECTS AND METHODS

### Subjects

Twenty football players who participated in this study have undergone transformed Brөstrom surgery from an orthopedic surgeon due to injured ankle ligament. The research ethics committee of the researcher's organization should explain the objectives and procedures of the research, the expected effects, and the potential risk factors, and then fully understand the purpose of the research and hope for voluntary participation (IRB-20171207-025). In order to achieve the purpose of the research, they were divided into two groups; vibration movement group and comparison group, each of 10 persons through wireless assignments. The physical characteristics of these groups are shown in Table 1.

### 2. Measurement Methods

#### 1) Physique and Body Composition

Measurements of height and weight were made using an automatic extension / weight meter, and the body mass index was calculated based on the measurements.

#### 2) Ankle movement function

##### (1) Isokinetic muscle strength test

Isokinetic muscle strength was measured using Biodex system pro III (Biodex Medical Systems Inc, USA). The angle of the chair set at 30 °. The angle of the chair is 30 °, the ankle is placed on the measuring plate, the hips are bent at 70 °, and the centerline of the patella and ankle are aligned side by side to minimize movement of shoes and measuring plate, and then fixed with a strap. Measurements were performed three times at an angular velocity of 30 ° / sec and 15 times at an angular velocity of 120 ° / sec to evaluate muscle strength and muscle endurance. Three exercises between each test were used to familiarize the measuring instrument and eliminate

**Table 2.** Physical characteristics of subjects

| | Age (yrs) | Height (cm) | Weight (kg) | BMI (kg/m$^2$) |
|---|---|---|---|---|
| Comparison group (10) | 22.10±1.45 | 178.78±4.59 | 72.07±4.55 | 22.53±0.63 |
| Exercise group (10) | 21.60±1.65 | 176.44±3.45 | 71.37±3.42 | 22.91±0.43 |
| p | .610 | .603 | .441 | .152 |

Values are means ± SD, p<.05

the influence of fatigue between sets to provide 30 seconds of rest.

### (2) Ankle joint proprioceptive sensory test

The proprioceptive sensory test of the ankle was performed using the Biodex system pro Ⅲ(Biodex Medical Systems Inc, U.S.A) to reproduce the position of the joint in the plantar flexion and dorsiflexion and eversion /inversion motion. Each subject is placed on a measuring chair and the feet to be measured are placed on the measuring plate, the talocrural joint and the knee are leveled, and the feet on the base and the measuring plate are fixed using a strap, and the average value was adopted as the record. The measurement was made by pressing the stop button at the memorized joint position to remember the position of the joint by holding the ankle flexion movement at 30° of the footwell and 10° of the stom-ach ulcer at 10° and at the angle of the outer 15° and inner 10° for 10 seconds at the set angle.

### 3) Vibration exercise program

Vibration was performed using a special instrument (Galileo 900, Novotec, Pforzheim, Germany). The instrument has a diaphragm with a certain interval of coordinates, so that it can observe the posture change according to the movement of the foot of the partici-pant, so that the posture and the position change during the exercise can be easily detected. In order to transmit the vibration stimulus generated by the device constantly to the body, the subjects were instructed to wear the same socks which was not slip-resistant. All subjects were instructed to main-tain an upright posture and to distribute the weight throughout the soles. All procedures were carried out to prevent accidents and injuries by maintaining accurate posture through guidance and observation. The exercise program was based on the previous research [13] and was based on the consultation of the specialist who performed the surgery of the subjects and the preparation exercise and the gymnastic exer-cise were 10 minutes each with fixed bicycle riding and stretching exercises, 30 minutes with vibration, 50 Min for 12 weeks. In the first one or two weeks after the initiation of exercise, various movements based on stand, squats and lunge were applied, starting with the low difficulty adjustment process, which was delivered by placing a chair at the back of the instrument and placing it on the vibrating appa-ratus one by one. In order to control the degree of difficulty, the attitude required to bend the knee joint was maintained by using a goniometer to maintain the correct posture. The intensity of exercise was determined by repeating the vibration, adjusting the number of sets, and gradually increased in consider-ation of the condition of the subject. The detailed exercise program is shown in Table 2.

### 4) Data processing method

All data were calculated using SPSS / PC statistical program. An independent T-test was conducted on the general characteristics of subjects for pre-homo-geneity validation. Independent T-test was used for significant differences between groups at the same time, and paired T-test was used for significant dif-ferences between groups. All statistical significance levels were set at less than .05.

**Table 2.** Vibration Exercise Program

| Period | Exercise program | Amount |
|---|---|---|
| Adaptor (1~2wk) | ■ Sit in a chair and put one foot on the instrument<br>■ Sit in a chair with two feet on the instrument<br>■ Stand behind the instrument and step up to the instrument<br>■ Standing behind the instrument and lifting it up<br>■ Standing on the instrument (knee flexion 135 °)<br>■ Standing on the instrument (upright) | ■ 10~12 reps<br>■ 1~3 sets<br>■ 30 min |
| Intensive exercise (3wks~12wks) | ■ Stand<br>■ Squat<br>■ Leg raise-front/side<br>■ Lunge<br>■ Calf raise<br>■ Toe raise | ■ 20 reps<br>■ 3~5 sets<br>■ 30 min |

**Table 3.** Isokinetic strength test of ankle joint (%)

| Measure/group | Pre-Test | Post-Test | within group | between group |
|---|---|---|---|---|
| Plantar flexor muscle strength 30°/sec | | | | |
| Comparison group | 183.07±17.38 | 204.35±17.80 | -3.901* | .726 |
| Exercise group | 177.91±14.26 | 176.79±17.75 | .173 | 3.467 |
| Plantar flexor muscle strength 120°/sec | | | | |
| Comparison group | 100.08±12.29 | 108.14±14.14 | -3.020 | .673 |
| Exercise group | 100.08±12.29 | 108.14±14.14 | -3.020* | .673 |
| Dorsiflexion muscle strength 30°/sec | | | | |
| Comparison group | 43.46±7.68 | 43.94±5.69 | -.396 | -.974 |
| Exercise group | 46.60±6.87 | 49.73±4.43 | -1.773 | -2.536 |
| Dorsiflexion muscle strength 120°/sec | | | | |
| Comparison group | 31.63±3.83 | 32.36±5.74 | -.749 | -.076 |
| Exercise group | 31.70±4.33 | 33.60±4.33 | -4.650* | -.545 |
| Eversion muscle strength 30°/sec | | | | |
| Comparison group | 73.37±9.82 | 76.04±7.37 | -1.548 | 2.426 |
| Exercise group | 64.65±5.71 | 77.86±4.83 | -4.285* | -.653 |
| Eversion muscle strength 120°/sec | | | | |
| Comparison group | 43.41±4.14 | 51.51±4.2 | -5.205* | 2.029 |
| Exercise group | 39.29±4.90 | 44.06±4.84 | -2.258* | 3.671 |
| Inversion muscle strength 30°/sec | | | | |
| Comparison group | 57.02±5.80 | 63.22±7.63 | -3.483* | .538 |
| Exercise group | 55.62±5.82 | 61.70±4.82 | -5.532* | .532 |
| Inversion muscle strength 120°/sec | | | | |
| Comparison group | 54.67±3.59 | 63.60±5.28 | -4.970* | 2.344 |
| Exercise group | 51.19±3.02 | 56.33±4.35 | -4.790* | 3.356 |

*p<.05, Values are means ± standard deviation

## RESULTS

### 1) Isokinetic strength of ankle joint

The result of isokinetic test of ankle joint is as follows. At the plantar flexor muscle strength of 30 ° / sec, there was a significant difference between the two groups. At 120 ° / sec, the exercise group showed a significant difference over time. There was a statistically significant difference between the exercise groups at dorsiflexion muscle strength of 120 ° / sec and valgus muscle strength of 30 ° / sec, and the comparison group also showed a significant difference at 120 ° / sec. In both groups, there was a significant difference at 30 ° / sec and 120 ° / sec.

### 2) Proprioceptive sense of ankle joint

The results of the proprioceptive sensory test of the ankle joint are as follows. There was no significant difference in dorsiflexion, but there was no significant difference between groups in plantar flexion, but significant change was observed in both groups.

**Table 4.** Proprioceptive sensory test of ankle joint (°)

| Measure/group | Pre-Test | Post-Test | within group | between group |
|---|---|---|---|---|
| Dorsiflexion | | | | |
| Comparison group | 5.11±1.27 | 3.90±1.13 | 3.125* | -.456 |
| Exercise group | 5.41±1.64 | 4.32±1.84 | 2.536* | -.619 |
| Plantar flexion | | | | |
| Comparison group | 7.04±1.30 | 5.96±2.08 | 2.097 | .694 |
| Exercise group | 6.48±2.19 | 4.79±1.31 | 2.162 | 1.499 |

Values are Mean ± Standard Deviation, p<.05

## DISCUSSION

The most frequent injury occurring in the ankle joint is the external sprain, and 85% of the injuries are caused by the varus, mainly involving the lateral external ligament injury. Anterior talofibular ligaments are functionally resistant to internal forces, and chronic external instability in the ankle blades, where constant instability occurs after external saliva, means instability lasting more than six months due to functional or mechanical instability, and frequency is reported from 15% to 48%. The treatment of chronic instability of the ankle joint can be classified into conservative treatment and surgical treatment. 80% to 90% of patients, including the most severe third-degree injuries, can achieve satisfactory functional recovery after conservative treatment, but the remaining 10% will require surgical treatment in the future. Preservation treatments can be considered for inherent sensory training, muscle strength exercises, flexibility exercises, and the use of footwear calibration and aids, but are less useful in patients with high activity, such as athletes. Surgical calibration is considered at this time [14]. After 12 weeks of rehabilitation by using a vibrating machine for soccer players who received modified Brӧstrom alcohol, this study obtained the following results.

The anatomical damage of the ankle joint leads to the weakening of the external and internal muscle strength including the weakening of the fibular muscle [7]. Many studies have applied various exercises to solve functional problems such as joint instability in ankle joints. Exercise induces a quantitative increase in muscle mass with activation of the muscle nerve, resulting in an increase in muscle strength and an effect on the control function of the muscle nerve that controls muscle contraction and relaxation. In this study, the constant velocity muscle force was measured to observe the change of muscle strength through vibration motion. The results of the study showed significant improvement in all measurement items, such as leg flexion, lateral flexion, external and internal muscle forces, compared to previous ones by performing vibration movements for 12 weeks. However, in the comparison group, both limb muscle strength and varus muscle strength were significantly improved compared with the pre-value. It is thought that various activities in daily life that require postoperative weight-bearing due to natural healing process according to time after the procedure were effective for improving muscle strength.

Joint position sensory test, measured to analyze the proprioceptive sensation of the ankle joint, is controlled by the proprioceptive sensory action of the joints and muscles. It transmits nerve signals to the central nervous system through the receptors distributed in skin, muscle, ligament, and transmit the signal back to skin, muscle, ligament, and tendon [15]. The proprioceptive sensation is reduced by fatigue accumulation and microalbuminuria due to overuse of peripheral ligaments, tendons, and nerves such as nerves through repetitive muscle contraction or exercise even without functional ankle instability [16].

There was no significant difference in dorsiflexion, but there was no significant difference between groups in plantar flexion, but significant change was observed in both groups. These results indicate that the subjects with instability in the ankle joint improved their proprioceptive senses by restoring the joint position sensation of the plantar flexion with improved strength through vibration exercise. It is difficult to be sure that exercise improves the dependent variable, and further research will be needed.

## CONCLUSION

In this study, we analyzed the effects of rehabilitation exercise on soccer players who had reconstructed with an ankle joint ligament injury through vibration exercise device. As a result, we could propose an effective exercise method to improve the ability and confirmed the applicability as an appropriate exercise program to prevent ankle injuries and help quick return. However, further studies including a variety of subjects who underwent modified Brӧstrom surgery would be necessary because of the improvement of some measurement variables in the comparison group without vibration exercise.

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