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Original Article

The effects of a strategic strength resistance exercise program on the isokinetic muscular function of the ankle

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Abstract. [Purpose] The purpose of this study was to investigate the effects of a strategic strength resistance exercise program on the isokinetic muscular function of the ankle joint. [Subjects] This study included 22 males in their twenties who were diagnosed with functional injury of the ankle joint. [Methods] To strengthen plantar flexion and dorsiflexion of the ankle joint, 8 weeks of weight, resistance band, and plyometric training, and training using props were performed. [Results] A medical examination by interview indicated that pain, swelling, instability, running, and support capacity of the ankle joint significantly improved with the strategic strength resistance exercise program. For the isokinetic peak torque of the ankles, significant differences were observed in right plantar flexion and bilateral dorsiflexion. [Conclusion] The strategic strength resistance exercise program is highly recommended for the functional stability of the ankle joint. Efficient exercise therapy is useful for muscle damage prevention, muscle strengthening, and functional interventions.
Key words: Ankle joint, Isokinetic, Muscular function

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INTRODUCTION

Ankle joints have a complicated anatomical and mechanical structure, and can have develop, which are among the most frequent injuries during normal physical activities[1–3)]. Ankle trauma can be categorized as acute or chronic; conservative treatment with rehabilitation training is crucial because chronic lateral instability of the ankle hinders mobility and reduces ambulatory status and balance capabilities[4–6)]. Frequent sprains of the ankle joint are caused by loss of muscular stability or inappropriate treatments, and collateral pain is reported as the most common cause[7)].

Patients with chronic ankle instability (CAI) have reduced balance capabilities, making it difficult to abruptly turn around or halt. This functional instability is due to damage of the mechanoreceptors in the joint region after ankle injury[6)]. Mechanical injuries can result in a limited range of motion, anthropometric changes, ligament laxity, and degenerative changes[4, 5, 8)]. Therefore, appropriate rehabilitation to enhance mobility is beneficial for the recovery of myofunction in both the general public and athletes[2, 9)]. In particular, patients with a severe reduction in proprioception due to an ankle sprain require improvement in muscular strength and postural control[10, 11)]. In this respect, resistance training is safe and effective in the prevention and rehabilitation of ankle sprains with CAI, and is a useful method for functional improvement[12)].

Proprioceptive ability is generally developed through muscle strength and balance training[13)]. Complex training of major joints should be performed efficiently[14)], and should result in pain relief, restoration of range of motion, recovery of muscle strength and endurance, and improvement in postural control[15)].

The present study was conducted to provide baseline data for an efficient rehabilitation exercise program. Isokinetic muscular strength was analyzed after 8 weeks of a strategic strength resistance exercise program in male subjects in their twenties who had pain or functional damage in the ankle joint.

SUBJECTS AND METHODS

This study recruited 22 male subjects who were orthopedically diagnosed with a functional injury of the ankle joint, and performed a strategic strength resistance exercise program for 8 weeks. Prior to enrollment, the purpose of this study and experimental methods were disclosed to all subjects, and participants voluntarily gave their signed informed consent. The study was approved by the HUFS University and the institution in which it was performed, and complied with the ethical standards of the Declaration of Helsinki. The average physical characteristics of the participants were: age

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26.41±4.16 years old, height 179.10±7.31 cm, and weight 75.84±8.07 kg.

Prior to the test, the degree of instability of each ankle joint was measured using the Ankle Score Scale (ASS), which is comprised of 8 subjective questions regarding pain, swelling, instability, stiffness, stair-climbing, running, work activities, and support ability. Each question is rated subjectively and converted to a 100-point scoring scale.

The muscular mobility of plantar flexion and dorsiflexion in the ankle were measured using isokinetic testing equipment (HUMAC NORM Testing and Rehabilitation System, CSMi Solutions, USA). To avoid hyperflexion or hyperextension injury during the test, each subject set their own range of motion by individual calibration, and the measurements were digitized and quantitated using the software provided by the manufacturer. To analyze comprehensive isokinetic myofunction in the ankle, values of peak torque at 30°/sec and peak torque per body weight were converted to percentiles (%). To measure the hamstring: quadriceps ratio of the ipsilateral thigh, peak torque of extension and flexion was measured, and the flexion to extension value was converted to a percentile (%).

The 8-week strategic strength resistance exercise program focused on the improvement of muscular strength, proprioceptive ability, and functional ability to improve complex instabilities of the ankle joint. The training consisted of three sets per week, with a total of 24 sets, at 60 minutes per set, and an increase in intensity every 2 weeks, following the progressive overload principle. In addition, the muscular strength program consisted of weight training, plyometric exercises without a load, and Thera-band exercises to strengthen muscles in the lower limbs, such as the quadriceps, hamstring, and gastrocnemius. Exercises to enhance proprioceptive ability were performed to improve the range of motion of the ankle joints, and props were used to improve static and dynamic postural controllability.

Statistical analysis was conducted using SPSS 20.0 (SPSS Inc., USA) for Windows. For all measurements, the average and standard deviation were calculated, and a paired t-test was adopted to test the differences in isokinetic myofunction; a medical questionnaire was complete before and after the 8-week strategic strength resistance exercise program. Statistical significance was set at α=0.05.

RESULTS

Results from the medical examination by interview before and after the 8-week program are shown in Table 1. The overall scores for the 8 questions regarding the ankle joint before and after participation in the program showed a statistically significant improvement ($p<0.001$) from 71.63±8.62 to 87.44±6.21, respectively.

Peak torque measurements in plantar flexion and dorsiflexion of the ankle before and after the 8-week program are shown in Table 2. Myofunction in right plantar flexion and bilateral dorsiflexion improved significantly.

Measurements of the peak torque per body weight in plantar flexion and dorsiflexion are shown in Table 3. The overall trend showed that the measurements increased, but this was not statistically significant.

Table 1. Results of the medical examination by interview regarding the ankle joint

Factors	Before program	After program
Pain	15.0±0.0	17.8±2.6***
Swelling	6.6±2.4	10.0±0.0***
Instability	17.2±2.6	21.6±2.4***
Stiffness	4.3±1.3	4.6±1.0
Stair climbing	8.1±2.5	9.1±2.0
Running	5.9±2.0	8.8±2.2***
Work activities	10.3±1.3	10.6±1.7
Support ability	4.3±1.3	5.0±0.0*
Total	71.6±8.6	87.4±6.2***

Unit: Point, Values are the mean±SD, *p<0.05, ***p<0.001

Table 2. Measurements of the isokinetic peak torque of the ankles

		Before program	After program
PF	Right	87.3±25.6	118.5±28.5*
	Left	93.9±34.0	112.7±29.3
DF	Right	25.9±5.8	34.1±6.9**
	Left	27.3±5.5	34.8±8.0*

Unit: Nm, Values are the mean±SD, PF: plantar flexion, DF: dorsi flexion, *p <0.05, **p <0.01

Table 3. Measurements of the peak torque/body weight of the ankles

		Before program	After program
PF	Right	124.8±38.3	149.6±33.7
	Left	133.8±46.9	142.7±39.7
DF	Right	37.1±9.1	43.4±7.8
	Left	39.6±8.7	44.5±9.2

Unit: %, Values are the mean±SD, PF: plantarflexion, DF: dorsiflexion

Table 4. Analysis of the isokinetic hamstring: quadriceps ratio of the ankles

	Before program	After program
Right	29.3±4.9	32.2±12.9
Left	31.9±8.1	33.2±16.0

Unit: %, Values are the mean±SD

Analysis of the isokinetic hamstring: quadriceps ratio in plantar flexion and dorsiflexion is shown in Table 4. Despite the lack of statistical significance, both the left and right ratios increased in the post-program measurements.

DISCUSSION

Weakness or unstable mobility in extension and flexion can cause instabilities in the major joints of the lower limb[17]. Patients with CAI have difficulty with fundamental physical

activities such as postural control and gait performance, and have limited functional activities, including postural sway; there is a risk of muscle injury because range of motion is decreased due to weakening and imbalance of lower limb strength[6]. The prevention of instability using self-evaluation with a medical questionnaire is desirable because untreated instability can induce abnormal external forces on the ankles, repeatedly resulting in an increase in instability factors[18].

A medical examination by interview and the Functional Ankle Instability Questionnaire are widely used tools[16, 19]. This study showed that an 8-week strategic strength resistance exercise program significantly improved pain, swelling, instability, and support ability of the ankle joint, as well as other factors that stabilized following the program.

Isokinetic strength testing mostly measures strength exhibition and balance ratios in the lower limb, and can be utilized for predicting isokinetic strength, relative diagnosis, and the possibility of occurrence[20]. Studies conducted on strength, balance, and functionality have revealed that weakening of the ankle joint can worsen functional instability and the possibility of reinjury[21], and that a combined exercise program is beneficial in the improvement of complex instability of the lower limb[22]. In addition, studies have shown that strength of plantar flexion is significantly different between jazz dance and ballet at an angular speed of 120°/sec, while strength of dorsiflexion is significantly different between jazz dance and ballet at an angular speed of 30°/sec[23]. Another study reported that dorsiflexion strength is higher in a concentric exercise group compared with an eccentric exercise group, when 12 male athletes with chronic ankle sprain were treated with 8-week isokinetic exercise programs[24]. Despite the differences in experimental methods, the majority of the results of previous studies that investigated abnormalities of ankles are consistent with the results of the present study.

In the present study, a medical examination by interview was performed and the change in isokinetic strength of the ankle was measured before and after a strategic strength resistance exercise program. Peak torque, relative strength, and isokinetic hamstring:quadriceps ratios for right plantar bilateral dorsiflexion increased. Notably, the differences in the answers to the medical questionnaire and the peak torque were statistically significant.

Thus, a strategic strength resistance exercise program is necessary for the functional stability of the ankle joint, and active treatments are recommended to prevent or treat chronic impairments. Strategic and efficient exercise intervention programs are needed to maintain strength in ankle joint reinjury.

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