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Impact of Combined Muscle Strength and Proprioceptive Exercises on Functional Ankle Instability

The purpose of this study was to implement a program of combined muscle stregth and proprioceptive exercises and to examine the impacts of these exercises on functional ankle instability(FAI). Experiments were conducted with 30 adult males and females in their 20s, and the exercise programs were implemented three days per week for four weeks. FAI was defined as a feeling of giving way after an ankle sprain and having a Cumberland ankle instability tool score of 24 points or less. The study subjects were randomly assigned to either a control group, a muscle-strengthening exercise group, or a combined muscle-strengthening and proprioceptive exercise group consisting of 10 subjects each. A Biodex isokinetic dynamometer was used to assess the subjects' ankle strength at selected speeds of 60° /sec and 120° /sec. The peak torque % body weight showed significant differences in plantar flexion, dorsiflexion, inversion, and eversion. There were also significant differences in proprioception. The results suggest that applying combined muscle-strength and proprioceptive exercises to subjects with FAI is a more effective intervention than applying only muscle-strengthening exercises.

Key words: *Strength; Proprioception; Functional Ankle Instability; CAIT*

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INTRODUCTION

Ankle sprain accounts for 7 - 10% of cases admitted to the emergency room in hospitals(1). According to studies, ankle sprain accounts for 15 - 20% of all sports-related injuries(2, 3). The ratio of reoccurrence of ankle sprain is reported to be as high as 30 - 40%(4).

Functional ankle instability(FAI) refers to the subjective feeling of an ankle giving way that remains after recurrent ankle sprains(5). The Cumberland ankle instability tool(CAIT) can be used to evaluate FAI. This evaluation tool has high reliability and validity(6).

Isokinetic equipment evaluates muscle functionality through peak torque, peak torque % body weight(PT%BW), average power, and total work. Isokinetic equipment has been used as a standard evaluation instrument(7, 8, 9). It is also utilized in a variety of areas due to its high reliability(10, 11).

Causes of FAI include muscle weakening and lack of proprioceptive senses. Proprioception plays an important role in neuromuscular interactions(12). These deliver various kinds of signals to the central nervous system through the muscle spindle and Golgi tendon organ located in ligaments, skin, muscles, tendons, and joint capsules to control the movement of the body(12).

Previous studies have examined the use of muscle-strengthening exercises, as well as exercises that improve proprioceptive sense and FAI(13, 14). Ankle instability is caused not only by deficiency of muscle strength but also by a lack of proprioception at the same time(15, 16, 17). Thus, execution of muscle-strengthening exercise and proprioceptive sense exercise separately may be ineffective interventions for FAI.

Therefore, the current study implemented a combination of muscle-strengthening and proprioceptive sense exercises and examined the impacts of these combined exercises on FAI.

METHODS

Subjects

In the present study, 30 healthy adult(7 males, 23 females) students in their 20s were selected from a university in the Gwangju region through open recruitment. Subjects with FAI were selected who had an ankle giving way as a result of a past ankle sprain and who had a CAIT score of 24 points or less(18). The study subjects were randomly assigned to either a control group(Group A), a muscle-strengthening exercise group(Group B), or a combined muscle-strengthening and proprioceptive exercise group(Group C) consisting of 10 subjects in each. In Group A, measurements were obtained before and after the experiment without any intervention. Group B and the Group C took part in exercise programs three days per week for four weeks. The purpose of this study was explained to the subjects, and all provided written consent. Table 1 shows the characteristics of the subjects.

Measurement of Strength

In the present study, the Biodex System Pro III(Biodex Medical Systems, Shirley, NY, USA) was used to measure the PT%BW to determine the muscle strength of the ankle. The subject was positioned in the chair with the angle inclined backward about 30°, and his/her shoe-clad foot was placed tightly on the measurement plate. The subject then bent his/her knee joint about 20° to 30°, with the knee bones of both legs aligned with the center of the ankle. Finally, the ankles, the femoral region, and the trunk were fixed using straps to minimize the range of errors due to compensation(Fig. 1). Plantar flexion and dorsiflexion were measured five times with a movement that began from 40° plantar flexion, progressed to 20° dorsiflexion, and then returned to plantar flexion. Inversion and eversion were measured five times in the aforementioned posture with a movement that began from 30° inversion, progressed to 20° eversion, and returned to inversion. The angular velocity was set to 60°/sec and 120°/sec while the subject rested for one minute between the angular velocities. These velocities are best for measuring muscle strength and are easy and safe for the subject(17, 19). In addition, the measurements obtained at this angular velocity are very reliable(20).

Fig. 1. Measurement of peak torque % body weight

Measurement of Proprioceptive Sense

The proprioception of the ankle was measured with the Biodex System Pro III. The subject wore an eye patch to minimize visual compensation in the aforementioned posture. The measurement was conducted in as quiet an environment as possible to minimize auditory compensation(Fig. 2). The exercise was performed with the subject keeping his/her ankle at the set position for 10 seconds, recognizing the angle and then finding the set position later. The subject pushed the button connected to the measuring instrument to confirm the position if he/she thought it was the set position. The absolute error between the set position and the position selected by the subject was recorded. The measurement was done in the sagittal plane, and the average value of three measurements was used(17).

Fig. 2. Measurement of proprioception

Strength Training and Combined Strength and Proprioception Training

Group B performed four types of exercises for 10 minutes using Thera-bands(The Hygenic Corporation, Akron, OH, USA): plantar flexion, dorsiflexion, inversion, and eversion.

Group C performed muscle-strengthening exercise followed by proprioceptive exercise for 20 minutes in total. For the proprioceptive exercises, the subjects stood on their FAI foot on an indoor floor with their other knee bent to 90°, placed their FAI foot on an Aero step, and then marched in place on a Posturomed for 10 minutes(21). Warm-up exercises and cool-down exercises were performed for five minutes each.

Data Analysis

The descriptive statistics of the means and standard deviations of all the data were analyzed using PASW version 18.0. To determine the normality of the distribution of the data, the Shapiro-Wilk test was used for all the parameters of the subjects. Tests for equality of variances among the three groups were done using one-way ANOVA. Duncan tests were conducted as ex post facto analyses. A significance level of p=0.05 was chosen.

RESULTS

The results of the between-groups comparison of PT%BW at an angular velocity of 60°/sec and 120°/sec are as follows. Significant differences were shown for plantar flexion, dorsiflexion, inversion, and eversion($p<.05$)(Table 2). The results of the post-hoc tests showed significant increases in the angular velocity at 60°/sec and 120°/sec in plantar flexion and inversion in Group B and Group C compared to Group A($p<.05$)(Table 2). At the angular velocity of 120°/sec, dorsiflexion showed significant increases in Group B and C compared to Group A($p<.05$)(Table 2). At the angular velocity of 60°/sec, eversion showed significant increases in Group C compared to Group A($p<.05$)(Table 2).

The proprioception showed significant differences between the groups. The results of post-hoc tests showed significant decreases in Group C compared to Group A($p<.05$)(Table 3).

Table 1. Characteristics of the subjects

	Group A	Group B	Group C
Sex(male/female)	2/8	3/7	2/8
Age(years)	23.4±2.1	23.5±2.7	22.9±2.3
Height(cm)	166.4±6.2	165.4±5.6	169.1±5.2
Weight(kg)	54.9±6.4	60.6±7.9	57.3±9.0
CAIT(score)	20.3±3.8	19.6±3.5	20.1±2.7

Mean±SD, *p<.05
Group A: control, B: muscle strength, C: muscle strength and proprioception

Table 2. Changes in peak torque/body weight in each group

		Angular velocity	Group A	Group B	Group C	F	p
Peak torque% body weight	Plantar flexion	60°	75.7±20.9	119.0±31.0†	111.9±37.2#	5.828	.008*
		120°	72.0±14.3	105.0±22.6†	101.1±32.4#	5.534	.010*
	Dorsiflexion	60°	35.2±14.0	51.9±14.5†	45.1±8.6	4.447	.021*
		120°	30.6±13.2	44.7±14.1†	48.4±9.9#	5.591	.009*
	Inversion	60°	33.1±10.2	47.1±8.5†	44.8±11.6#	5.430	.010*
		120°	27.9±9.2	37.7±8.5†	37.4±9.9#	3.644	.040*
	Eversion	60°	16.9±3.9	20.8±4.1	22.6±32.0#	5.934	.007*
		120°	17.2±1.2	21.3±4.2	21.6±1.6	5.103	.013*

Mean±SD, *p< .05
Differences in Group B and Group C compared to Group A(†: p<.05)(#: p<.05)
Group A: control, B: muscle strength, C: muscle strength and proprioception

Table 3. Changes in proprioception in each group

	Group A	Group B	Group C	F	p
Proprioception(°)	3.1±1.3	2.6±1.0	1.6±0.8#	5.239	.012*

Mean±SD, *p< .05
Differences in Group B and Group C compared to Group A(#: p<.05)
Group A: control, B: muscle strength, C: muscle strength and proprioception

DISCUSSION

Ankle sprain is caused by excessive inversion and plantar flexion at the same time(22), leading to pain, instability, and ankle arthritis(23). In this study, combined muscle-strengthening and proprioceptive exercises were applied to subjects with FAI, and the impacts of the exercises were examined using PT%BW and proprioception measurements.

The PT%BW refers to muscle strength per unit weight(24, 25), which can be evaluated relatively between subjects(26). Current study have revealed significant differences in plantar flexion, dorsiflexion, inversion, and eversion. Our result is consistent with the results of a previous study where patients with chronic ankle instability showed a significant difference in PT%BW after muscle-strengthening and proprioceptive exercise(27). However, Group B had no significant difference in eversion compared to Group A. In addition, Group C had no significant difference in dorsiflexion and eversion at 60°/sec and 120°/sec compared to Group A. Riemann et al. reported that an adaptation period was required for all interventions(28). Therefore, if the current intervention had lasted six, eight, or 12 weeks, a significant difference would be expected(29).

Proprioception is an important element of ankle instability. In a previous study(30), a group with FAI displayed a significant difference in proprioceptive sense errors in the sagittal plane. Another study reported a significant difference between balance in groups with stable ankles and FAI ankles(18). Proprioception differences were reduced via a rehabilitation program(16). Hupperets et al. found that proprioception exercise was effective in preventing recurrent ankle injury(31). In this study, Group C showed a significant difference compared to Group A, whereas there were no significant differences between Groups A and B. This is consistent with the results of a previous study(32). Therefore, combined muscle-strengthening and proprioceptive exercises are more effective than simple muscle-strengthening exercises.

The limitations of this study are that the intervention was applied only for four weeks and that the subjects were limited to those in their 20s. In addition, proprioceptive senses were measured only in the sagittal plane. Applying the intervention for at least six weeks in a future study with diverse age groups and comparing the proprioception of the subjects in the horizontal plane would shed greater light on the ability of combined muscle-strengthening and proprioceptive exercises to improve FAI.

CONCLUSION

In this study, combined muscle-strengthening and proprioceptive exercises were applied to individuals with FAI, and the following conclusions were drawn. Significant increases were observed in the PT%BW of Group B and Group C compared to the control group, Group A. Significant decreases were also seen in proprioception in Group C compared to Group B. Therefore, the results suggest that applying combined muscle-strength and proprioceptive exercises to those who have FAI is a more effective intervention than applying only muscle-strengthening exercises.

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