

# Which Treatment is More Effective for Functional Ankle Instability: Strengthening or Combined Muscle Strengthening and Proprioceptive Exercises?

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**Abstract.** [Purpose] The purpose of this study was to implement combined muscle strengthening and proprioceptive exercises to examine the effects of combined exercises on functional ankle instability. [Subjects and Methods] Experiments were conducted with 30 adult males and females. 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 each. In Group A, measurements were only conducted before and after the experiment without any intervention, whereas the exercise programs for Group B and Group C were implemented three days per week for four weeks. [Results] Muscle strength showed significant increases in Groups B and C compared with the control group during plantar flexion, dorsiflexion, inversion, and eversion. The Cumberland ankle instability tool showed significant increases in Group B and Group C compared with Group A and significant increases in Group C compared with Group B. [Conclusion] Applying combined muscle strengthening and proprioceptive exercises to those who have functional ankle instability is more effective than applying only muscle strengthening exercises.

**Key words:** Functional ankle instability, Strength, Cumberland ankle instability tool

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## INTRODUCTION

According to recent studies on lower extremity injuries, ankle sprains have the highest incidence rate, reaching 206 per 100,000 persons per year, and they most frequently occur in children and adolescents<sup>1)</sup>.

Functional ankle instability (FAI) refers to the subjective feeling of an ankle giving-way that remains as a result of an ankle sprain<sup>2)</sup>. The causes of FAI include muscle weakening and the lack of proprioceptive sense<sup>3-7)</sup>. In previous studies, both muscle strength and proprioception have been associated with ankle instability. For instance, muscle strengthening exercises and well-planned proprioceptive exercises can

help those who develop FAI after an ankle injury, particularly with their normal activities, and can prevent unnecessary operations<sup>4)</sup>. Since chronic ankle instability is related to the combination of the lack of proprioceptive sense and eversion muscle weakening, combined exercise programs focused on improving proprioception and muscle strength are necessary<sup>5)</sup>.

The Cumberland ankle instability tool (CAIT) is the first tool to measure the degree of FAI. This evaluation tool consists of nine questions and has high reliability and validity<sup>8)</sup>. Isokinetic dynamometers are often used to measure ankle muscle strength. They can measure and analyze muscle functions such as peak torque, average power, and total works simultaneously in one muscle contraction exercise, have higher objectivity and accuracy than muscle function evaluations through isometric or isotonic exercises, and can evaluate muscle functions precisely using diverse angular velocities<sup>9, 10)</sup>.

Although both insufficient muscle strength and the lack of proprioceptive sense exist simultaneously in those with FAI, studies on them are insufficient. Therefore, the pur-

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**Table 1.** Characteristics of study participants

	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<0.05. Group A, control; Group B, strength; Group C, strength and proprioception

pose of this study was to implement a combination of exercises for these two problems and to examine the effects of the combined exercises using ankle muscle strength and CAIT scores.

## SUBJECTS AND METHODS

### Subjects

In this study, experiments were conducted on 30 healthy adult males and females in their 20s selected from among students at a university in the Gwangju region through open recruitment. Subjects were selected who had an ankle giving way as a result of a past ankle sprain and who had a CAIT score not exceeding 24 points. The purpose of this study was explained to the subjects, and their written agreement to the experiment was obtained. The general characteristics of the subjects are given in Table 1.

### Methods

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 exercises group (Group C) consisting of 10 subjects each. In Group A, measurements were only conducted before and after the experiment without any intervention, whereas the exercise programs for Group B and Group C were implemented three days per week for four weeks.

As Group B exercises, a total of four types of exercises, plantar flexion, and dorsiflexion, inversion, and eversion, were performed for 10 minutes using TheraBands (The Hygenic Corporation, Akron, OH, USA). The Group C exercise program consisted of the same exercises as those implemented in the muscle strengthening group (Group B) followed by proprioceptive exercises. For the proprioceptive exercises, subjects stood on their instable foot on an indoor floor with the knee on the other side bent to 90°, placed the instable foot on an Aerostep, and marched in place on a Posturomed for 50 sec, with each being performed in order of precedence<sup>11</sup>). A total of four sets were performed for 10 minutes. Warm-up exercises and cool-down exercises were performed for five minutes each.

In this study, a Biodex III isokinetic dynamometer (Biodex Medical Systems, Shirley, NY, USA) was used to measure ankle muscle strength. Wearing a pair of shoes, each subject reclined the chair by 30°, placed his/her feet on the measuring plate at 0°, placed his/her knee joints at

20–30°, and took a posture so that the patellae and the center of the ankles were aligned parallel to each other; the trunk, femoral region, and ankles were fixed using straps to minimize the range of errors due to compensation. Plantar flexion and dorsiflexion were measured once with a movement that began from 40° plantar flexion, progressed to 20° dorsiflexion, and then returned to plantar-flexion. Inversion and eversion were measured once in the aforementioned posture with a movement that began from 30° inversion, progressed to 20° eversion, and returned to inversion. Each subject was allowed to rest for one minute after each movement. The angular velocity was set to 60°; this is best for measuring muscle strength because it is easy and safe, and a large number of motor units are necessary at low angular velocities<sup>12</sup>). In addition, measurement at this angular velocity is highly reliable<sup>13</sup>). The degree of FAI was examined using the CAIT.

The descriptive statistics of the means and standard deviations of all data measured in this study were produced using the PASW version 18.0 statistical program. Shapiro-Wilk tests were conducted to determine the normal distribution of each measurement item. The extended  $\chi^2$  test and one-way ANOVA were performed to test the homogeneity of the groups. Differences among Group A, Group B, and Group C were analyzed using one-way ANOVA. Duncan tests were conducted as post-hoc analyses. To verify the significance of all statistical analyses, the significance level  $\alpha$  was set to 0.05.

## RESULTS

The results of the between-groups comparison of peak torque at an angular velocity of 60° are as follows. Significant differences were shown for plantar flexion, dorsiflexion, inversion, and eversion ( $p<0.05$ ). The results of post-hoc tests showed significant increases in Group B and Group C compared with the Group A (Table 2).

The CAIT showed significant differences between the groups ( $p<0.05$ ). The results of post-hoc tests showed significant increases in Group B and Group C compared with Group A and significant increases in Group C compared with Group B (Table 2).

## DISCUSSION

Effective rehabilitation from ankle sprains is difficult because the cause of recurrence has not been clearly es-

**Table 2.** Changes in peak torque and CAIT in each group

		Group A	Group B	Group C
Peak Torque (N)	Plantar flexion	45.8±21.6	75.2±26.4*	71.6±26.3*
	Dorsiflexion	18.4±7.3	27.5±9.5*	30.7±5.4*
CAIT (score)	Inversion	17.8±5.5	28.7±6.6*	26.2±8.9*
	Eversion	10.2±2.2	14.3±1.9*	14.7±3.0*
CAIT (score)		20.5±1.8	22.8±2.3*	25.4±1.9*†

Mean±SD. \* Difference compared with Group A ( $p<0.05$ ). † Difference compared with Group B ( $p<0.05$ ). Group A, control; Group B, strength; Group C, strength and proprioception

tablished despite the fact that ankle sprains have been extensively researched and investigated<sup>14</sup>). Repeated ankle sprains induce FAI<sup>15</sup>), and injuries to the muscles, ligaments, and tendons around the ankle<sup>16</sup>) and the lack of proprioceptive sense<sup>6</sup>) have been reported as the causes of FAI. In this study, combined muscle strengthening and proprioceptive exercises were applied to subjects who had FAI, and the effects of the exercise were examined using muscle strength and the CAIT.

Isokinetic dynamometers help to quantify and understand current conditions of the ankle. Peak torque can be defined as the maximum torque produced during the five repetitions and has been known as the most important index of an individual's muscle strength<sup>17, 18</sup>). In this study, when combined muscle strengthening and proprioceptive exercises were performed, peak torque showed significant increases in Groups B and C compared with Group A at an angular velocity of 60° during plantar flexion, and dorsiflexion, inversion, and eversion. These results are consistent with the results of previous studies indicating that when muscle strengthening exercises were applied to subjects who had FAI, muscle strength increased significantly<sup>19, 20</sup>).

The CAIT is a simple, valid, and reliable FAI evaluation tool. In a previous study<sup>21</sup>), when dynamic neuromuscular training was applied to the ankle for six weeks, the CAIT score improved from 4 points to 27 points<sup>22</sup>). In this study, Groups B and C showed significant increases compared with Group A, and when Groups B and C were compared with each other, Group C showed significant increases compared with Group B. Based on this, proprioceptive exercises in combination with muscle strengthening exercises helped to improve ankle stability<sup>23</sup>). Therefore, combined muscle strengthening and proprioceptive exercises are more effective than muscle strengthening exercises only.

The limitations of this study include that the intervention was only applied for four weeks and that the subjects were limited to individuals in their 20s. The effects of combined muscle strengthening and proprioceptive exercises could be determined with greater accuracy in future studies if the intervention is applied for at least six weeks and the results are measured in subjects from diverse age groups. In conclusion, the current study found that applying combined muscle strengthening and proprioceptive exercises to individuals who have FAI is more effective than applying only muscle strengthening exercises.

## REFERENCES

- Lambers K, Ootes D, Ring D: Incidence of patients with lower extremity injuries presenting to US emergency departments by anatomic region, disease category, and age. *Clin Orthop Relat Res*, 2012, 470: 284–290. [[Medline](#)] [[CrossRef](#)]
- Ji SW, Kim HS, Kwon KW, et al.: The ankle strength, balance and functional ability of the adolescent volleyball players with functional ankle instability. *Korean J Phys Educ*, 2004, 43: 567–577.
- Urgüden M, Kızılay F, Sekban H, et al.: Evaluation of the lateral instability of the ankle by inversion simulation device and assessment of the rehabilitation program. *Acta Orthop Traumatol Turc*, 2010, 44: 365–377. [[Medline](#)] [[CrossRef](#)]
- Willems T, Witvrouw E, Verstuyft J, et al.: Proprioception and muscle strength in subjects with a history of ankle sprains and chronic instability. *J Athl Train*, 2002, 37: 487–493. [[Medline](#)]
- Hartzell HD, Spaulding SJ: Eccentric/concentric ratios at selected velocities for the invertor and evertor muscles of the chronically unstable ankle. *Br J Sports Med*, 1999, 33: 255–258. [[Medline](#)] [[CrossRef](#)]
- Freeman M: Instability of the foot after injuries to the lateral ligaments of the ankle. *J Bone Joint Surg*, 1965, 47: 669–677.
- Kim MC: Isokinetic muscular strength of the lower limbs and balance in soccer players with functional ankle instability. Master's thesis, Sports Medicine Graduate School of Sports Science Dankook University, 2008, pp 6–8.
- Sawkins K, Refshauge K, Kilbreath S, et al.: The placebo effect of ankle taping in ankle instability. *Med Sci Sports Exerc*, 2007, 39: 781–787. [[Medline](#)] [[CrossRef](#)]
- Olivier N, Rogez J, Masquelier B: Benefit of isokinetic evaluation of knee before and after anterior cruciate ligament reconstruction in soccer players. *Ann Readapt Med Phys*, 2007, 50: 564–569. [[Medline](#)] [[CrossRef](#)]
- Sole G, Hamrén J, Milosavljevic S, et al.: Test-retest reliability of isokinetic knee extension and flexion. *Arch Phys Med Rehabil*, 2007, 88: 626–631. [[Medline](#)] [[CrossRef](#)]
- Eils E, Rosenbaum D: A multi-station proprioceptive exercise program in patients with ankle instability. *Med Sci Sports Exerc*, 2001, 33: 1991–1998. [[Medline](#)] [[CrossRef](#)]
- Brech GC, Ciolac EG, Secchi LL, et al.: The effects of motor learning on clinical isokinetic performance of postmenopausal women. *Maturitas*, 2011, 70: 379–382. [[Medline](#)] [[CrossRef](#)]
- Wennerberg D: Reliability of an isokinetic dorsi flexion and plantar flexion apparatus. *Am J Sports Med*, 1991, 19: 519–522. [[Medline](#)] [[CrossRef](#)]
- Refshauge KM, Kilbreath SL, Raymond J: The effect of recurrent ankle inversion sprain and taping on proprioception at the ankle. *Med Sci Sports Exerc*, 2000, 32: 10–15. [[Medline](#)] [[CrossRef](#)]
- Ross SE, Guskiewicz KM: Effect of coordination training with and without stochastic resonance stimulation on dynamic postural stability of subjects with stable ankle. *Clin J Sport Med*, 2006, 16: 323–328. [[Medline](#)] [[CrossRef](#)]
- Hertel J: Functional instability following lateral ankle sprain. *Sports Med*, 2000, 29: 361–371. [[Medline](#)] [[CrossRef](#)]
- Camargo PR, A'vila MA, Asso NA, et al.: Muscle performance during isokinetic concentric and eccentric abduction in subjects with subacromial impingement syndrome. *Eur J Appl Physiol*, 2010, 109: 389–395. [[Medline](#)] [[CrossRef](#)]
- Kim HH: The effect of isokinetic training program in according to the muscle contraction type on the thigh muscles strength. Master's thesis, Sport Industry Graduate School Namseoul University, 2008, pp 42–46.
- Hagen M, Lescher S, Hennig E, et al.: High resistance shank muscle strength training changes foot behavior during a sudden ankle supination.

- Br J Sports Med, 2013, 47: e3. [[CrossRef](#)]
- 20) Smith BI, Docherty CL, Simon J, et al.: Ankle strength and force sense after a progressive, 6-week strength-training program in people with functional ankle instability. *J Athl Train*, 2012, 47: 282–288. [[Medline](#)]
- 21) Hiller CE, Refshauge KM, Bundy AC, et al.: The Cumberland ankle instability tool: a report of validity and reliability testing. *Arch Phys Med Rehabil*, 2006, 87: 1235–1241. [[Medline](#)] [[CrossRef](#)]
- 22) O’Driscoll J, Kerin F, Delahunt E: Effect of a 6-week dynamic neuromuscular training programme on ankle joint function: a case report. *Sports Med Arthrosc Rehabil Ther Technol*, 2011, 3.
- 23) Kynsburg A, Pánics G, Halasi T: Long-term neuromuscular training and ankle joint position sense. *Acta Physiol Hung*, 2010, 97: 183–191. [[Medline](#)] [[CrossRef](#)]