Influence of Isokinetic Strength Training of Unilateral Ankle on Ipsilateral One-legged Standing Balance of Adults

Sung Min Son, MS, PT1), Kyung Woo Kang, MS, PT1), Na Kyung Lee, MS, PT1), Seok Hyun Nam, MS, PT1), Jung Won Kwon, MS, PT1), Kyung Kim, PhD, PT1)*

1) Department of Physical Therapy, College of Rehabilitation Science, Daegu University: 15 Jilyang, Gyeongsan-si, Kyeongbuk 712-714, Republic of Korea

Abstract. [Purpose] The purpose of the current study was to investigate the changes in one-legged standing balance of the ipsilateral lower limb following unilateral isokinetic strength training. [Subjects and Methods] Thirty healthy adult volunteers were randomly assigned to either a training group or a control group, so that each group included 15 subjects. Subjects in the training group performed unilateral ankle isokinetic exercises of the dominant leg using the Biodex 3 PRO System for a period of four weeks. Ipsilateral one-legged standing balance was evaluated before and after the intervention with three stability indexes of balance using the Biodex System: Anterior-Posterior Stability Index (APSI), Medial-Lateral Stability Index (MLSI), and Overall Stability Index (OSI). [Results] Comparison of pre- and post-test data revealed significant improvements in strength values (dorsiflexion, plantarflexion, eversion, and inversion) and stability indexes (APSI, MLSI, OSI). [Conclusion] These results suggest that ankle strengthening exercise can be considered as a form of exercise that may assist individuals with improvement of balance.

Key words: Postural balance, Isokinetic exercise, Strength training

INTRODUCTION

Functional balance is defined as the ability to maintain a position and to adjust posture during functional movement and mobility, such as the movement from one postural position to another or moving from one location to another4). The maintenance of balance is a complex phenomenon, and it is influenced by a range of several sensorimotor functions, including muscular strength, proprioception, and the visual and vestibular sensory system2, 3).

A standing posture has a high center of gravity (COG) which is maintained over a relatively small base of support8). Previous studies have identified two discrete strategies of postural control, and ankle and hip strategies have often been used to describe maintenance of postural control through specific actions at those two joints4, 5). Strength of the ankles has been found to correlate with postural stability and functional tests6, 7). Several studies have also demonstrated the importance of foot and ankle musculature in the optimal performance of functional motor tasks, such as walking, running, and jumping8, 9). However, to date, most studies associated with strength training and balance for the lower limbs have been limited to the hip or knee joint10–12), and little is known about the effects of balance after isokinetic training for the ankles. In general, an efficient way to increase balance ability is resistance training for the hip and knee joint10–12).

The purpose of this study was to investigate the changes in the Anterior-Posterior Stability Index (APSI), Medial-Lateral Stability Index (MLSI), and Overall Stability Index (OSI) in one-legged standing balance of the ipsilateral lower limb following unilateral isokinetic strength training for the ankle.

SUBJECTS AND METHODS

Thirty healthy and physically active subjects were recruited as volunteers for this study. The subjects were randomly assigned to a training (n=15) or control group (n=15). The baseline demographic characteristics of the subjects enrolled in the study were as follows. Each group consisted of five male and 10 female subjects. The mean age, height, weight, and foot length of subjects in the control group were 23.6 ± 2.35 years, 162.9 ± 8.24 cm, 56.1 ± 12.66 kg, and 241.7 ± 16.65 mm, respectively, and those of the training group were 23.4 ± 2.03 years, 165.5 ± 5.71 cm, 55.5 ± 6.37 kg, and 245.7 ± 14.05 mm, respectively. The subjects had not participated in a resistance training program for at least six months. Subjects were excluded if they had; a diagnosed neurologic disease or disorder; acute back or lower-limb musculoskeletal problems, such as strain, sprain, surgery, or fracture; or neurologic or vestibular impairment that prevented single-limb stance. All the subjects understood the purpose of this study and provided their written informed consent prior to their participation in the study in...
analyses of variance, and two-way ANOVA with repeated
length. All data were evaluated using separate univariate
terms of the baseline data for age, height, weight, and foot
of differences between the training and control groups, in
and after the four-week intervention period.

Balance measurements using BSS
90°at the start of the assessment, and maintain the position
ahead, lift the untrained knee from the floor and flex it to
structed to fold their arms across the chest and look straight
-aged over three evaluations. For this test, subjects were
ing and control group was assessed at level 10 (Level 12 is
around a group mean. One-legged stance between the train-
viations of fluctuations around the zero point rather than
 improvements in ankle strength (dorsiflexion, plantarflexion,
eversion and inversion) and stability parameters (ALSI, MLSI
and OSI), two-way ANOVA with repeated measures (groups: training group, control group) × 2 (test
sessions: pre-test, post-test) on the two dependent variables.
The level of statistical significance was chosen as 0.05.

RESULTS

No significant differences in terms of distributions of
gender, age, height, weight, and foot length were observed
between the two groups. Table 1 shows the parameters of
ankle strength (dorsiflexion, plantarflexion, eversion and
inversion) and stability parameters (ALSI, MLSI and OSI)
at the pre- and post-tests of the two groups. In terms of the
parameters of ankle strength (dorsiflexion, plantarflexion,
eversion and inversion) and stability parameters (ALSI,
MLSI and OSI), two-way ANOVA with repeated measures
showed significantly large main effects of group (p<0.05),
time (p<0.05), and group-by-time interaction (p<0.05). In
addition, changes in pre-test and post-test values were sig-
ificant in the training group (p<0.05). However, there were
no significant differences in the control group (p>0.05).
These data indicate that the training group achieved signifi-
cant improvements in ankle strength and stability over the
4-week intervention period.

DISCUSSION

In the current study, we attempted to investigate the ef-
effect of unilateral isokinetic strength training for the ankle
on the one-legged standing balance of the ipsilateral lower
limb. We acknowledge that no studies have been conducted
to investigate the effect of ankle training with isokinetic ex-
ercise on the one-legged standing balance of the ipsilateral
lower limb. Our findings show there were significant im-
provements in ankle strength (dorsiflexion, plantarflexion,
eversion and inversion) and in the APSI, MLSI and OSI sta-
ability indexes of the ipsilateral lower limb in one-leg stand-
ing balance in the training group, compared to the gender-
and age-matched control groups.

In order to support the whole body, muscle action around
the ankle is important, because it is responsible for control

Table 1. Comparison of balance ability of the training and control group

| Parameters     | Training group (n=15) | Control group (n=15) | Change Values |
|----------------|-----------------------|----------------------|---------------|
|                | Pre (°)               | Post (°)             |                |
| Dorsiflexion   | 8.21 ± 3.34           | 10.64 ± 4.85         | 2.43 ± 3.19*  |
| Nm             | 15.51 ± 3.47          | 15.51 ± 3.42         | –0.15 ± 1.96  |
| Plantarflexion | 18.50 ± 6.72          | 31.43 ± 11.39        | 12.93 ± 11.99*|
| Nm             | 21.2 ± 7.28           | 20.27 ± 5.38         | –0.97 ± 5.21  |
| Eversion       | 5.80 ± 2.80           | 9.61 ± 3.25          | 3.81 ± 1.98*  |
| Nm             | 4.32 ± 2.47           | 4.51 ± 2.37          | 0.19 ± 1.76   |
| Inversion      | 6.45 ± 2.37           | 11.03 ± 5.22         | 4.58 ± 4.19*  |
| Nm             | 6.19 ± 3.17           | 5.28 ± 2.70          | –0.91 ± 1.68  |
| APSI (°)       | 0.52 ± 0.33           | 0.36 ± 0.16          | –0.16 ± 0.18* |
|                 | 0.51 ± 0.21           | 0.50 ± 0.20          | –0.01 ± 0.17  |
| MLSI (°)       | 0.47 ± 0.21           | 0.26 ± 0.09          | –0.21 ± 0.167*|
|                 | 0.47 ± 0.22           | 0.47 ± 0.24          | –0.01 ± 0.250 |
| OSI (°)        | 0.76 ± 0.39           | 0.57 ± 0.23          | –0.19 ± 0.205*|
|                 | 0.75 ± 0.34           | 0.75 ± 0.28          | 0 ± 0.214     |

* significant difference between pre- and post-test (*p<0.05)
† significant difference compared with the control group (p<0.05)

Nm (Newton meter)
of this joint. One of the most common interventions for improving postural stability is physical exercise, such as isokinetic exercise and progressive resistance exercise. Our findings indicate that isokinetic exercise for the ankle improved balance ability. These findings are in agreement with those of several previous studies, which suggested that strength exercise targeting the lower limb muscles improves balance ability. We think that balance improvement may be a result of better coordination of the muscles around the ankle after isokinetic training. In addition, increase in balance ability may be related to promotion of the proprioceptive senses, due to strength exercise, since proprioceptive function is an important factor of balance ability. Strength exercise can activate proprioceptive functions, which might provide feedback to the joint, increase stimulation of the mechanoreceptors, such as the muscle spindle, Golgi tendon organ and Ruffini nerve endings around the joint. Hilberg et al. used isometric muscular strength training for knee joints, and reported improved performances in the one-legged standing test and proprioceptive function after exercise by a training group, compared with control group. On the basis of these results, we think that balance improvement is influenced by activation of motor coordination and proprioceptive sense in the ankle joint due to the strength training.

Previous studies have reported that the relation between strength training exercise and balance is a good indicator of dynamic stability in healthy and older adults. Our findings emphasize that ankle strengthening exercise can be considered as a form of exercise that may assist individuals in improvement of balance. However, in this study, it is possible that the training for ankle strength may have simultaneously influenced the activation of the muscles around the knee joint, which is the joint closest to the ankle, as well as the muscles around ankle. In addition, the results of our study should be interpreted with consideration of potential limitations. First, isokinetic training was performed for only four weeks. If the intervention were carried out for a longer period of time, the result would possibly show more significant improvements. Second, conduct of a study with older subjects is needed in order to investigate the therapeutic efficacy of isokinetic strength training, because older subjects may have a greater need for balance improvement than younger subjects with regard to the prevention of falls. Future studies may be needed in order to clarify these issues.

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