J. Phys. Ther. Sci.
25: 1313–1315, 2013

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

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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

(This article was submitted Apr. 8, 2013, and was accepted May 29, 2013)

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 another[1)]. 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 system[2, 3)].

A standing posture has a high center of gravity (COG) which is maintained over a relatively small base of support[4)]. 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 joints[4, 5)]. Strength of the ankles has been found to correlate with postural stability and functional tests[6, 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 jumping[8, 9)]. However, to date, most studies associated with strength training and balance for the lower limbs have been limited to the hip or knee joint[13–15)], 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 joint[10–12)].

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

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

Parameters	Training group (n=15)		Control group (n=15)		Change Values	
					Training group (n=15)	Control Group (n=15)
	Pre	Post	Pre	Post	Post-Pre	Post-Pre
Dorsiflexion (Nm)	8.21 ± 3.34	10.64 ± 4.85*†	8.66 ± 3.47	8.51 ± 3.42	2.43 ± 3.19*	−0.15 ± 1.96
Plantarflexion (Nm)	18.50 ± 6.72	31.43 ± 11.39*†	21.2 ± 7.28	20.27 ± 5.38	12.93 ± 11.99*	−0.97 ± 5.21
Eversion (Nm)	5.80 ± 2.80	9.61 ± 3.25*†	4.32 ± 2.47	4.51 ± 2.37	3.81 ± 1.98*	0.19 ± 1.76
Inversion (Nm)	6.45 ± 2.37	11.03 ± 5.22*†	6.19 ± 3.17	5.28 ± 2.70	4.58 ± 4.19*	−0.91 ± 1.68
APSI (°)	0.52 ± 0.33	0.36 ± 0.16*†	0.51 ± 0.21	0.50 ± 0.20	−0.16 ± 0.188*	−0.01 ± 0.171
MLSI (°)	0.47 ± 0.21	0.26 ± 0.09*†	0.47 ± 0.22	0.47 ± 0.24	−0.21 ± 0.167*	−0.01 ± 0.250
OSI (°)	0.76 ± 0.39	0.57 ± 0.25*†	0.75 ± 0.34	0.75 ± 0.28	−0.19 ± 0.205*	0 ± 0.214

* significant difference between pre- and post-test (*p<0.05)
† significant difference compared with the control group (p<0.05)
APSI (Anterior-Posterior Stability Index), MLSI (Medial-Lateral Stability Index), OSI (Overall Stability Index)
Nm (Newton meter)

accordance with the ethical standards of the Declaration of Helsinki.

Unilateral training was performed using the Biodex 3 PRO System (Biodex, Inc., Shirley, NY, USA) for strength training of ankle dorsiflexion and plantar flexion, and inversion and eversion. Subjects in the training group received training five times per week for four consecutive weeks. Isokinetic exercise were performed on the right side in five sets of 10 repetitions at the angular velocity of 60°/s with a rest period of 2 min between sets. Subjects who complained of ankle pain during the training period were excluded from this study. Subjects in the control group attended health education programs, such as fall prevention, balance, exercise, and were given general information regarding health promotion for one hour each week.

For balance testing, we used a commercial balance device, the Biodex Stability System (BSS) (Biodex Medical systems, Shirley, NY, USA), a movable balance platform providing up to 20° of surface tilt in all directions. Measures of postural stability include the stability indexes of APSI, MLSI, and OSI. These indices are standard deviations of fluctuations around the zero point rather than around a group mean. One-legged stance between the training and control group was assessed at level 10 (Level 12 is the most stable, 1 is the least stable) stability of the BSS for a period of 20 s. The stability indexes were calculated from the degree of tilt deviation from horizontal and were averaged over three evaluations. For this test, subjects were instructed to fold their arms across the chest and look straight ahead, lift the untrained knee from the floor and flex it to 90°at the start of the assessment, and maintain the position as accurately as possible. Balance measurements using BSS of the training and control group were performed before and after the four-week intervention period.

Statistical analyses were performed using SPSS version 18.0 software. The independent t-test was used for analysis of differences between the training and control groups, in terms of the baseline data for age, height, weight, and foot length. All data were evaluated using separate univariate analyses of variance, and 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 significant 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 significant improvements in ankle strength and stability over the 4-week intervention period.

DISCUSSION

In the current study, we attempted to investigate the 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 exercise on the one-legged standing balance of the ipsilateral lower limb. Our findings show there were significant improvements in ankle strength (dorsiflexion, plantarflexion, eversion and inversion) and in the APSI, MLSI and OSI stability indexes of the ipsilateral lower limb in one-leg standing 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 of this joint[8, 9]. One of the most common interventions for improving postural stability is physical exercise, such as ioskinetic exercise and progressive resistance exercise[16, 17]. 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[12–14]. 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[18]. 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[19–21]. Hilberg et al.[19] 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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