

Original Article

# The effects of ankle loads on balance ability during one-leg stance

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**Abstract.** [Purpose] The purpose of this study was to evaluate the effects of ankle loads on balance ability and to suggest an appropriate load amount. [Subjects and Methods] The 31 healthy subjects randomly put 0%, 1%, and 2% body weight loads on their ankles using a strap, and limit of stability was measured using a Biorescue system. Limits of stability were measured for 10 seconds using their dominant leg in the left, right, forward, and backward directions. [Results] All values for limit of stability increased significantly with the 1% load compared with the 0% load during a one-leg stance. However, all values except for the backward limit of stability showed a significant decrease with the 2% load compared with the 1% load. There was a significant difference between the 0% and 2% loads. [Conclusion] Application of loads on the ankles can be used as a training method for improving balance ability, and to increase efficiency, it is appropriate to apply 1% of the subject's body weight.

**Key words:** Balance, Loads, One-leg stance

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## INTRODUCTION

Balance is fundamental to the smooth performance of various daily activities. It includes factors such as posture control, standing straight reaction, and protection reaction<sup>1)</sup>. Since body segments are connected to each other, a change in body alignment in one part induces compensatory movement in other parts and eventually induces postural sway and instability. Asymmetrical posture and imbalanced weight loads can cause increased postural sway<sup>2)</sup>.

There are some training programs to assist with the recovery of balancing ability, such as proprioceptive training, which uses visual feedback and biofeedback training, lower limb muscle training, and weight shifting training<sup>3)</sup>. Moreover, there is an exercise that puts loads on a specific part of a patient's body and requires the patient to walk. Previous studies report that applying loads to the lower limbs activates the gluteus medius when the patient is mid-stance during flatland walking and inclined-surface walking<sup>4, 5)</sup>. The ankle joints control small sways of the body and are related to the ability to recover one's balance, and the one-leg stance test is the best way to check balance control ability<sup>6, 7)</sup>.

Currently, there are many studies being conducted on the changes in muscle activity depending on the load applied. However, there are insufficient number of studies have fo-

cused on balance. Therefore, this study applied loads to the ankle joints to evaluate the effects on balance ability and to suggest an appropriate load amount.

## SUBJECTS AND METHODS

This study involved 31 healthy adult male and female subjects. All subjects understood the purpose of the study and signed a written consent form. Also, the study was approved by the Daegu University Faculty of Rehabilitation Sciences Human Ethics Committee. The study excluded people with abnormality in balance control ability and people who had sustained damage to or had received surgery on their ankle joints or surrounding tissues. The subjects' mean age was 21.9±3.7, mean height was 166.4±6.7 cm, and mean weight was 61.9±12.6 kg.

The subjects randomly put 0%, 1%, and 2% body weight loads on their ankle using a strap, and their limit of stability (LOS) was measured using a BioRescue system (AP 1153 RM Ingenierie, Rodez, France)<sup>8)</sup>. LOS can be used to measure dynamic balance ability by having subjects move their body's center of gravity as far as possible in the following eight directions as indicated by arrows: left, right, forward, backward and toward the midpoints of each direction. LOS was measured for 10 seconds using their dominant leg in the left, right, forward, and backward directions. The collected data were analyzed using PASW Statistics for Windows, Version 18.0. To compare the dynamic balance ability based on the 0%, 1%, and 2% loads, this study used repeated one-way ANOVA. Post hoc analysis was performed with the LSD test, and the statistical significance level was set at  $\alpha = 0.05$ .

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**Table 1.** Comparison of limits of stability in accordance with ankle loads during a one-leg stance (Unit: cm)

	0%	1%	2%
Right	335.7±218.6	413.3±206.6*	350.8±185.0 <sup>‡</sup>
Left	224.5±148.6	293.8±193.1*	238.6±162.7 <sup>‡</sup>
Forward	303.6±211.3	397.9±235.8*	321.3±192.9 <sup>‡</sup>
Backward	260.3±162.3	309.2±162.7*	268.1±146.4
Total	565.0±358.5	707.0±385.9*	591.0±331.0 <sup>‡</sup>

Mean±SD. \*Significant difference between 0% and 1% ( $p<0.05$ ).

<sup>‡</sup>Significant difference between 1% and 2% ( $p<0.05$ ).

## RESULTS

All values for LOS (left, right, forward, backward and total) increased significantly with the 1% load compared with the 0% load during a one-leg stance. However, all values except for the backward LOS showed a significant decrease with the 2% load compared with the 1% load. There was a significant difference between the 0% and 2% loads (Table 1).

## DISCUSSION

Normal sensory input and central integration are necessary to maintain balance, which requires proper musculoskeletal support<sup>9</sup>. Application of a load to the lower limbs improves muscle strength and range of motion. Moreover, strengthening the muscles around the ankle provides increased ankle stability<sup>10</sup>.

This study was conducted to confirm the effect of load on balance ability and to determine the proper load to use for improvement of balance. The results showed that the left, right, forward, and total LOS values increased significantly when a 1% load was applied compared with the 0% and 2% loads. The range of movement toward the back significantly increased when the 1% load was applied compared with the 0% load.

The gluteus medius produces most of the power of the hip joint in a one-leg stance. Lee reports<sup>4</sup>) that the gluteus medius is most activated when a 1% load is applied to the ankle during a one-leg stance. The limit of stability was increased most effectively when a 1% weight load was applied vertically because the gluteus medius was maximally activated, and this affected the stability of the one-leg stance. The limit of stability was decreased when the 2% weight load was

applied because the muscle activation of the gluteus medius did not increase in proportion to the provided weight load, a result similarly found in other studies. Instead, the heavy load induced compensatory action to tolerate it, which seemed to disturb balance control. Applying a 1% load on the ankle increased the weight load on the body and resulted in proper musculoskeletal support, which in turn improved integrated control and balance sense. Jung et al.<sup>11</sup>) applied loads to the lower limbs when they conducted aquatic treadmill walking training for chronic stroke patients. The group with loads applied to the knees and ankles showed increased in proportion of stance phase. The group with loads on ankles showed improved stability and symmetry of the knees and ankles. Their results support the results of this study.

Applying weight loads on the ankles improves stability and symmetry of the knees and ankles, which in turn improves balance ability. Therefore, application of loads on the ankles can be used as a training method for improving balance ability. To increase the efficiency of the training method, it is appropriate to apply 1% of the subject's body weight.

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