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Original Article

Analysis of the correlation between the differences in muscle strengths between the bilateral lower extremities and postural stability in healthy adults

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Abstract. [Purpose] The purpose of this study was to examine the correlation between the differences in muscle strengths between the bilateral lower extremities and the level of postural sway that indicates postural stability. [Subjects and Methods] A total of 49 students (18 males and 31 females) at Y University in Gyeongsangnam-do, South Korea, participated in this study. Partial correlation analysis was performed to determine the effects of sway length and velocity on the differences in muscle strengths between the lower extremities. [Results] Both sway length and sway velocity showed a negative correlation with the difference in bilateral ankle dorsiflexion strength. Both sway length and sway velocity showed a positive correlation with the difference in bilateral hip flexion strength. [Conclusion] Difference in left-right muscle strengths of hip flexion and ankle dorsiflexion can affect postural stability when the levels of lower extremity muscle strengths are excluded.
Key words: Postural sway, Muscle strength, Postural balance

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INTRODUCTION

Postural stability is similar in meaning to static balance control ability and is measured mostly using postural sway[1)]. Postural stability is used as a risk factor for falling in the elderly and to predict injury in athletes[1, 2)]. Previous studies showed that stronger lower extremity muscle strength increased postural stability, and lower extremity strengthening exercise is widely recommended to prevent falls in the elderly[3)].

Since the lower extremities consist of the two legs, not only the absolute level of muscle strength but also the balance of muscle strength of the lower extremities is important. In addition, when the difference in muscle strength between the bilateral lower extremities is great, it largely affects postural stability[4–6)]. The present study hypothesized that the amount of influence on postural stability would be different among each joint of the lower extremities. Therefore, the aim of this study was to analyze the correlation between the differences in muscle strengths between the bilateral lower extremities and the level of postural sway that indicates postural stability.

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SUBJECTS AND METHODS

A total of 49 students (18 males and 31 females) attending Y University in Gyeongsangnam-do, South Korea, participated in this study. The mean age, height, and weight of the participants were 19.8 ± 1.2 years, 165.6 ± 65 8.0 cm, and 59.1 ± 10.6 kg, respectively. The selection criteria for subjects were as follows: no disease that might affect the test and no visual impairment, hearing damage, or nervous system or vestibular organ problems. Those who were unable to understand the nature of the experiment were excluded. Information about the study was provided to the subjects before participation in accordance with the ethical principles of the Declaration of Helsinki were provided to all subjects prior to their participation, and all agreed to participate in the project by providing written informed consent.

A hand held dynamometer (Commander Muscle Tester, JTECH Medical, Midvale, UT, USA) was used measure lower extremity muscle strengths. Flexion and extension in the bilateral hip joints, knee joints, and ankle joints were measured. Differences in muscle strength between the left and right sides were recorded as absolute values.

The hip joint was measured with the knee flexed at 90 degrees in a supine position, the knee joint was measured in a sitting position, and the ankle joint was measured with the leg extended in a supine position so that the subjects could move parallel to the ground and would not be affected by gravity[7)].

The subjects stood with their feet shoulder width apart on a BioRescue (RM Ingenierie, Rodez, France) for one

Table 1. Correlation between the left-right differences in muscle strengths and balance ability

		AD (lbs)	AP (lbs)	KF (lbs)	KE (lbs)	HF (lbs)	HE (lbs)
		3.70±3.32	4.95±4.37	3.73±3.53	4.84±3.77	4.81±3.56	5.25±3.91
Sway length (cm)	36.96±7.31	−0.35*	−0.09	0.16	−0.09	0.28*	0.12
Sway velocity (cm/s)	0.61±0.12	−0.29*	−0.09	0.14	−0.13	0.27*	0.17

*p<0.05 (mean±SD). AD: ankle dorsiflexion difference; AP: ankle plantar flexion difference; KF: knee flexion difference; KE: knee extension difference; HF: hip flexion difference; HE: hip extension difference

minute, and sway length and sway velocity for one minute were measured. All measurements were conducted three times and reported as the mean value ± standard deviation.

IBM SPSS Statistics for Windows (version 20.0) was used to analyze the data. The partial correlation coefficient was used to examine the correlation between differences in left-right muscle strengths and balance ability. Individual muscle strength was considered a confounding factor, and ankle dorsiflexion was used as a controlling variable to exclude it. The statistical significance level used was $\alpha = 0.05$.

RESULTS

Both sway length and sway velocity had a negative correlation with the difference between ankle dorsiflexion strengths ($p<0.05$). Both sway length and sway velocity had a positive correlation with the difference between hip flexion strengths ($p<0.05$) (Table 1).

DISCUSSION

This study analyzed the correlation between the difference in left-right muscle strengths and postural stability in healthy adults by measuring the muscle strengths of the left- and right-side ankle joints, hip joints and knee joints. A dynamometer was used to measure lower extremity muscle strength in each joint, and one-minute postural sway velocity and length were measured to evaluate postural stability.

This study used the partial correlation coefficient because stronger lower extremity muscles controls posture better due to absolute difference in individual muscle strength and previous studies have reported about this[3, 8].

However, the influence of absolute individual lower extremity muscle strengths on postural control could have introduced bias into the results of this study, the aim of which was to analyze the correlation between left-right muscle strengths and postural stability. Therefore, ankle dorsiflexion strength was set as the controlling variable to control the effect of absolute muscle strengths.

This study showed significant results for ankle dorsiflexion and hip flexion.

There were negative correlations between the differences in left-right ankle dorsiflexion strengths and sway length ($r = -0.35$) and between the differences in left-right ankle dorsiflexion strengths and velocity ($r = -0.29$). There were positive correlations between the differences in left-right hip flexion strengths and sway length ($r = 0.28$) and between the differences in left-right hip flexion strengths and velocity ($r = 0.27$). These results show that greater differences between ankle dorsiflexion strengths decrease postural sway and greater differences between hip flexion strengths increase postural sway.

An increase in postural sway means lower postural stability and causes an increase in the risk of injury[1, 2]. Previous studies showed that a greater imbalance in lower extremity muscles decreases postural stability and increases the risk of damage[4–6]. These results from previous studies are consistent with the results for hip flexion but not those for ankle dorsiflexion in this study.

Ankle dorsiflexion showed a negative correlation; it seems that the subjects usually applied force to both their feet in reciprocal directions to reduce movement in the mediolateral direction, since mediolateral instability increases the risk of injury more than anteroposterior instability does[9]. This study did not show strong correlations. However, it is meaningful in that there was correlation when the levels of lower extremity muscle strengths were excluded; the levels of lower extremity muscle strengths largely affect balance ability. In conclusion, differences between left-right muscle strengths of hip flexion and ankle dorsiflexion can affect postural stability when the levels of lower extremity muscle strengths are excluded.

Limitations of this study included that the study population was small and the subjects were only young adults. Further study should be performed with various age groups and populations.

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