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Original Article

The Relationship Between Hip Abductor and Pelvic Drop During Lateral Step Down in the Elderly

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Background: The lateral step down (LSD) is a form of stair negotiation used by the elderly because it requires less movement of the lower extremity. Although it is necessary to study the amount of pelvic drop and the strength of a hip abductor during LSD for intervention, limited studies have investigated the relationship between the amount of pelvic drop and strength of a hip abductor during LSD in elderly people.

Objects: This study aimed to determine the relationship between the amount of pelvic drop on an unsupported leg and the strength of the hip abductor during LSD in the elderly.

Methods: Thirty elderly people (male: 17, female: 13) were recruited. Subjects performed the LSD task, and the evaluator measured and the amount of pelvic drop on an unsupported side. Also, the isometric strength of the hip abductor was measured in a supine position.

Results: We found significant relationships between the strength of the hip abductor and the amount of pelvic drop ($r = -0.386$). The average hip abductor strength normalized by body weight was 1.06 N/kg (max: 1.99, min: 0.52) and the average contralateral pelvic drop (CPD) angle was 4.16° (max: 15.3, min: 0).

Conclusion: Our results indicated that the strength of the hip abductor had a moderate correlation with the CPD during a LSD in the elderly. Hip abductor weakness could translate into altered movement of the pelvis.

INTRODUCTION

Aging is a multifactorial process that causes qualitative and quantitative changes in muscles, which can lead to muscle strength reduction and disability in the elderly [1-4]. Inactivity cause the skeletal muscle to atrophy, change in contractile properties, and fiber-type switching. And the decline of the neuromuscular system lead decreased strength, loss of independence in the elderly [2]. These changes in the elderly affect adversely the activities of daily living such as standing, walking, and stair climbing, which require use of the lower extremities [5,6]. In particular, the step down task is one of the most difficult activities of daily living [7].

Gluteus muscle weakness increases with advancing age [8]. In the gluteal muscle, the hip abductor group includes the gluteus medius, gluteus minimus, and tensor fascia lata [8,9]. Among these muscles, the gluteus medius is a key muscle in weight-bearing tasks [10]. The gluteus medius is an important muscle for controlling the frontal plane motion of the pelvic hip complex. It plays a major role in stabilizing the hip during a unilateral stance to prevent the pelvis from dropping on the unsupported side [11,12]. One of the causes of step down task difficulty may be weakness of the hip abductor [13].

In step down strategies, the representative methods are lateral step down (LSD) and forward step down [14,15]. In healthy young people, the forward step down strategy is used in activities of daily living. However, in elderly people who have muscle weakness, the LSD method may be chosen as an alternative method because the forward step down strategy requires greater movement of the lower extremities than the LSD method [14,15]. Elderly people use the LSD method as a compensatory strategies adopted included unsupported lower limbs to better control the lowering of the body and place the foot more safely within the step below [15]. Previous authors [14,15] identified that the LSD method resulted in lesser hip adduction, knee flexion, knee adduction than the forward step down method. These findings suggested that the LSD method is a less demanding biomechanical method than the forward step down method, and it requires less control of the lower extremities.

It is important to control pelvic stability and the gluteus muscle in the frontal plane when LSD is performed. The LSD is a commonly used screening test for lower extremity functions, such as muscle strength of lower limbs, contralateral pelvic drop (CPD), knee valgus and rear foot eversion [16-18]. Previous studies reported a significant correlation between the amount of CPD and the hip abductor in young people (or athletes) during LSD [19,20]. Although LSD is frequently chosen for stair negotiation in the elderly, few studies have investigated the relationship between CPD and the hip abductor strength during LSD in the elderly. Investigating the relationship between CPD and the hip abductor muscle strength during LSD in elderly people could provide useful information for evaluating and managing the movement patterns of the lower extremities during LSD in elderly people. Therefore, this study aimed to determine the relationship between the hip abductor strength and CPD during LSD tasks in the elderly.

MATERIALS AND METHODS

1. Participants

Table 1 shows the results that 30 healthy older adults recruited at senior organizations. Individuals were eligible for inclusion if they were ≥ 60 years of age and were free from any medical condition or injury affecting their stair activity or balance and able to stair walk without the use of a hand rail [6]. Subjects with any other recent (6 months) or current spinal or lower extremity pathology were excluded. Also, we excluded the subjects who cannot performed this task. A total of 35 participants were screened, and five participants who met the exclusion criteria were excluded. Thirty subjects (age: 66.9 ± 6.02 years; height: 158 ± 8.73 cm; weight: 60.23 ± 11.09 kg; body mass index: 23.81 ± 3.01 kg/m^2) were finally included in this study. Details of the experimental procedures were explained to all subjects, and informed consent was obtained from them when they were enrolled, which was approved by the Institutional Review Boards of Yonsei University Mirae campus (IRB no. 1041849-202204-BM-075-01).

Table 1. General characteristics (N = 30)

Variable	Mean ± SD	Minimum	Maximum
Age (y)	66.9 ± 6.02	60	79
Height (cm)	158 ± 8.73	145	178
Weight (kg)	60.23 ± 11.09	46	90
Body mass index (kg/m^2)	23.81 ± 3.01	19.47	33.30
Hip abductor strength (N/kg)	1.06 ± 0.39	0.52	1.99
Contralateral pelvic drop (°)	4.16 ± 2.93	0	15.3

Values are presented as mean ± standard deviation or number only.

2. Hip Abductor Strength

The hip abductor isometric strength was measured by a Smart KEMA tension sensor (KOREATECH Co., Ltd., Seoul, Korea), and the initial tension was controlled on a belt by 3 kgf. The force data were recorded in the form of maximal voluntary isometric contraction of the hip abductor strength. The force data measured by sensors were transmitted to a tablet and calculated using the Smart KEMA application (KOREATECH Co., Ltd.). The hip abductor isometric strength measured by the Smart KEMA tension sensor showed excellent intra-rater and inter-rater test reliability [21]. The belt length was adjusted in the start position to measure the hip abductor strength. The assessor controlled the participant's hiking of the pelvis during hip abduction. The hip and knee joint of the dominant leg was extended to 0°, then participants were instructed to hold maximal strength for 5 seconds, and the middle 3 second was analyzed to generate an average (Figure 1). All data were divided according to the participants' weights for normalization. Two trials were applied for the data analyses. Participants rested for 30 seconds after each trial and for 5 minutes between the hip abductor strength measurements to prevent muscle fatigue. The hip abductor strength was calculated as average values of two trials in the dominant side.

Figure 1. Measurement of hip abduction muscle strength.

3. Contralateral Pelvic Drop

Two retroreflective circular markers (14 mm in diameter) were placed at both anterior superior iliac spines (ASIS). Retroreflective circular markers were affixed by the same physical therapist for each participant. Two-dimensional videos of the LSD were captured using a regular smartphone (Galaxy S10 5G; Samsung Inc., Seoul, Korea) with a video recording application (4K, 3840 × 2160 pixels at 60 fps). The phone was placed on a tripod 60 cm in height and 200 cm from the step box. The video recording data were analyzed using an available software package (Kinovea® version 0.8.15; Kinovea, Bordeaux, France) [22,23]. Two-dimensional data were collected at a sampling rate of 60 frames per second. The CPD was evaluated during LSD by video recordings in 2D. The CPD was defined by two lines between the horizontal line starting at the ASIS of the stance phase and a second line connecting the ASIS of the stance and swing leg. The larger this angle is, the more the CPD [24] (Figure 2).

4. Procedures

The participants performed three trials of LSD on the dominant leg. The subjects performed LSD using a 15-cm step box [25]. The participants trained the task correctly. Before performing the task, the subject was given practice three times to become familiar with the task. For this trial, the participant stood upright, facing straight forward, with feet shoulder-width apart. To avoid compensatory movements of the upper limbs, the participants were asked to cross their arms behind their backs while performing the task. Participants were instructed to slowly lower the non-dominant leg until the heel slightly contacts the floor (Figure 2). A metronome at 60 beats per minute was used for the standardized movement speed. The LSD time lasted 3 seconds and participants returned to the starting position by the third beat of the metronome, beeping at a frequency of 1 beat per second [26]. The mean values of the measurements obtained in the three trials were used for the data analysis.

5. Statistical Analysis

The data were analyzed using PASW version 18.0 (IBM Co., Armonk, NY, USA) for Windows. The Kolmogorov–Smirnov test was used to assess data normality. The Pearson correlation coefficient was used to examine the relationship between the strength of the hip abductor and CPD. Hopkins [27] suggested threshold values of trivial ($r = 0.0$ to 0.1), small (0.1 to 0.3), moderate (0.3 to 0.5), large (0.5 to 0.7), very large (0.7 to 0.9), and extremely large (0.9 to 1.0). In all analyses, $p < 0.05$ was considered statistically significant.

RESULTS

The Kolmogorov-Smirnov test shows normality of the data ($p > 0.05$). The average hip abductor strength of 30 subjects was 64.84 N. The average hip abductor strength normalized by body weight was 1.06 N/kg. The minimum value of the hip abductor strength normalized by body weight was 0.52 N/kg and the maximum value was 1.99 N/kg. The average CPD angle was 4.16°. The minimum value of the CPD angle was 0° and the

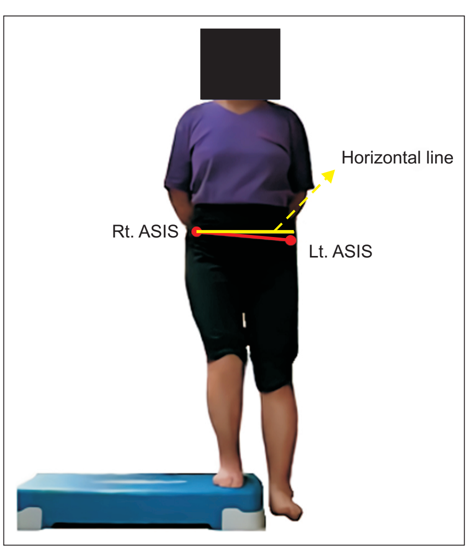

Figure 2. Measurement of pelvic drop during lateral step down. Rt., right; Lt., left; ASIS, anterior superior iliac spines.

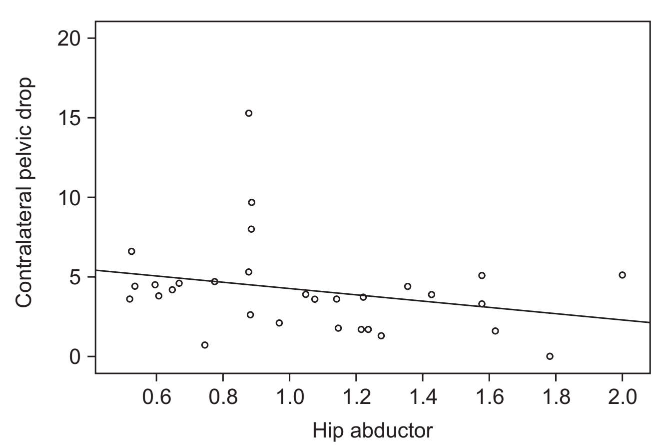

Figure 3. Scatterplot between contralateral pelvic drop and hip abductor strength.

maximum value was 15.3° (Table 1). The hip abductor strength had a moderate correlation with the CPD ($r = -0.386$, $p = 0.035$) (Figure 3).

DISCUSSION

Previous studies have investigated pelvic drop related to strength of the hip abductor in various tasks [19,20]. The hip abductor torque of pitchers is negatively correlated with CPD during the single leg forward step down [19]. Also, the gluteus medius isometric torque showed a negative relationship with left and right pelvic drop during running [20]. Our study found a negative relationship between CPD and the hip abductor strength during LSD in the elderly, and it was confirmed that the elderly group had results similar to those of previous studies [19,20]. These results may help in designing intervention programs to improve the function of LSD in the elderly.

Nakagawa et al. [28] investigated the relationship between pelvic kinematics and gluteal muscle activation during a single-leg squat in two groups: a group with patellofemoral pain syndrome (PFPS) and a control group. They reported that CPD was 10.3° ± 4.7° during the single-leg squat in subjects in the PFPS group and 7.4° ± 3.8° in the control group. Rabin et al. [18] also investigated the relationship between 3-dimensional pelvic kinematics and visual ratings of pelvic movement during LSD in healthy participants. They reported that CPD was 4.5° ± 4.2° during LSD in subjects without pelvic drop group and 8.1° ± 2.7° during LSD in subjects with the pelvic drop group. In our study, the average of the CPD was 4.16° ± 2.93° during LSD in elderly subjects. From these results, the data of CPD in the elderly subjects in this study was similar with that in healthy young subjects in Rabin et al. [18]'s study. Also, in our study, there was a negative relationship between CPD and the hip abductor strength, which is consistent with previous results. These results support that the weaker the hip abductor muscle, the greater the CPD in previous studies.

The correlation coefficient between the strength of hip abductor and CPD is –0.386 in this study. This result is assessed as a moderate (0.3 to 0.5) correlation [27]. Zipser et al. [19] reported a significant negative correlation between the hip abductor strength and CPD during single-leg squats in athletes ($r = -0.28$, $p = 0.021$). Also, Selistre et al. [29] reported a significant negative correlation between the hip abductor strength and CPD during gait in patients with knee osteoarthritis ($r = -0.51$). Like previous studies, the result of our study could not show a large correlation of 0.5 or higher. The reason for this result is that the hip abductor affects not only CPD, but also many factors such as hip adduction angle [29], knee valgus [16], knee extensor strength [30] and range of motion of ankle dorsiflexion [31], which may be because only the CPD was considered in this study.

Our study has several limitations that should be considered when interpreting the results. First, our study uses the 2-dimensional kinematic analysis to evaluate kinematic data that occur in three dimensions. Since compensation, such as pelvic rotation and pelvic anterior tilt, may occur during LSD, it is necessary to measure the movement of pelvic rotation and pelvic anterior tilt using 3-dimensional motion analysis in future studies. Second, we only considered CPD and did not investigate the knee, ankle, and trunk kinematics that may also have affected knee, ankle, and trunk control, such as knee flexion, extension, ankle dorsiflexion, plantarflexion, knee valgus, and trunk side-bending. Another limitation is that cross-sectional design restricts a cause-and-effect association of the strength of the hip abductor with physical function and pain. Further study is needed to confirm whether gluteus medius strengthening exercises can reduce CPD in the elderly.

CONCLUSIONS

This research aimed to investigate the correlation between the hip abductor strength and CPD during LSD in the elderly. Our results indicated that the hip abductor strength had a moderate correlation with the CPD during LSD in the elderly. It was confirmed that the elderly group had similar results to the previous studies of the young adult group [19,20]. These results may help in designing intervention programs to improve the function of LSD in the elderly.

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CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article are reported.

AUTHOR CONTRIBUTION

Conceptualization: OK. Data curation: OK. Formal analysis: OK. Investigation: OK. Methodology: SJ, HY. Project administration: YL, SJ. Resources: HY. Supervision: YL, SJ. Validation: YL, SJ. Visualization: HY. Writing - original draft: OK. Writing - review & editing: YL, SJ.

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